MINERALS

ECONOMIC & REGIONAL DEVELOPMENT AGREEMENT

Final Report
TASK 4 - Geotechnical Database
for Ground Control
Geomechanical Model
DATA RETRIEVAL SYSTEM

by

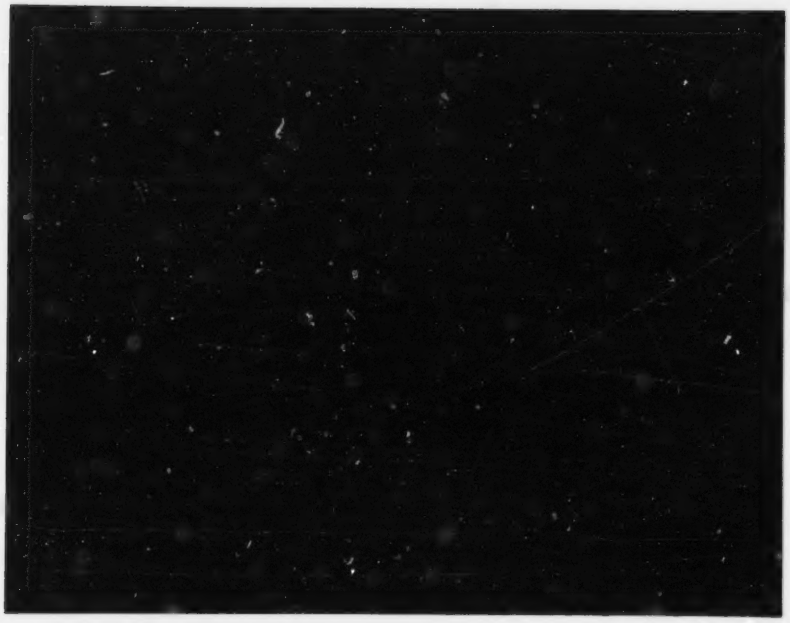
Inco Limited, Thompson Division
Thompson, Manitoba

March 1990

MICROME

Canada

Manitoba



CANADA - MANITOBA

MINERAL DEVELOPMENT AGREEMENT

RESEARCH & DEVELOPMENT IN MANITOBA MINES

Work on the project was conducted under the auspices of Canada Centre for Mineral and Energy Technology, Energy, Mines and Resources Canada under the Canada/Manitoba Mineral Development Agreement.

DSS File NO. 14SQ.23440-4-9147-4
DSS Contract Serial No. OSQ84.00404
CANMET Project NO. 4-9147-4
CANMET Scientific Authority: Y.S. Yu

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96pp

90-05660/2

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GEOTECHNICAL DATABASE FOR GROUND CONTROL

Geomechanical Model

Data Retrieval System

This has been prepared as part of the

TASK 4
Geotechnical Database for Ground Control
of the
Canada/Manitoba Mineral Development Agreement

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EXECUTIVE SUMMARY

A user friendly geotechnical database retrieval system is set up to aid in the evaluation of mine stability and design. This system provides storage for pertinent mine data and allows Engineering and Geology departments the use of software grid manipulation or contour overlays to determine structural trends to aid in predicting potential ground problems. Contour plots of the mining geometry, and selected geological plots are constructed to determine if any relationships exist between wall slough or poor ground conditions and different geological parameters.

SOMMAIRE

Un système interactif de récupération de données géotechniques a été mis en place pour faire l'évaluation de la stabilité et du design de la mine. Ce système permet le stockage des données pertinentes de la mine et donne, au département de génie et de géologie, un logiciel permettant la manipulation des grillages ou des différents contours géologiques pour déterminer les tendances structurales afin de prédire les problèmes potentiels de terrain. Les contours geométriques de la mine et certaines conditions géologiques peuvent être construits pour déterminer s'il existe des relations entre la stabilité des murs ou la faiblesses du terrain et les différents paramètres géologiques.

Table of Contents

1.0 SUB-TASK 2 - DEVELOPMENT OF GEOTECHNICAL DATA BASE RETRIEVAL SYSTEM FOR UNDERGROUND MINES 1
1.1 General 1

2.0 HISTORY 1

3.0 OBJECTIVES 1
3.1 General - Data Collection 2
3.2 Method - Data Collection 2
3.2.1 Joint Sets 3
3.2.2 Widths of the Orebody, Footwall, and Hangingwall 3
3.2.3 Q - Values 3
3.2.4 Mine Geometry 4
3.2.5 Ground Failure 4
3.3 Surfer: A Brief Overview 4
3.3.1 Introduction to Surfer 4
3.3.2 Description 5
3.3.3 Applications 6
3.3.4 Benefits and Limitations of Surfer 7
3.3.5 Conclusions 8
3.4 Digit Program 8
3.4.1 Overview of Digit 8
3.4.2 Setting up Digit 9
3.4.3 Digitizing Point Data 12
3.4.4 Digitizing Line Data 13

4.0 RESULTS 15
4.1 Dip Results 15
4.2 Width Results 16
4.2.1 Footwall Width Results 16
4.2.2 Hangingwall Width Results 17
4.2.3 Ore Width Results 17
4.3 Mine Geometry Results 18
4.3.1 Orebody Mine Geometry Results 18
4.4 Results Comparing Methods of Producing Regular Grids 19

List of Figures

Figure No.	Description	
Figure 1A	1A Mine Layout	20
Figure 1B	1B Mine Layout	21
Figure 1C	1C Mine Layout	22
Figure 2	CANMET - Design Input Data	23
Figure 3	Borehole Record Output	24
Figure 4	Rock Mass Quality Data Sheet	25
Figure 5	Sample Surfer Process Flow Chart	26
Figure 6	Rock Mass Classification Data Sheet	27
Figure 7	Idealized X-section showing Rock Mass Quality Domains	28
Figure 8A	Mining Methods - 1A Mines Layout	29
Figure 8B	Mining Methods - 1B Mines Layout	30
Figure 8C	Mining Methods - 1C Mines Layout	31
Figure 9	Rock Failure Positions - 1C Mines Layout	32
Figure 10	Time to Create a Grid	33
Figure 11	1C Footwall Width - Window	34
Figure 12A	1A Dips - Extracted Data	35
Figure 12B	1A Dips - Contour	36
Figure 12C	1A Dips - Background 67.7°	37
Figure 12D	1A Dips - Perspective View	38
Figure 13A	1B Dips - Extracted Data	39
Figure 13B	1B Dips - Contour	40
Figure 13C	1B Dips - Background 60.6°	41
Figure 13D	1B Dips - Perspective View	42
Figure 14A	1C Dips - Extracted Data	43
Figure 14B	1C Dips - Contour	44
Figure 14C	1C Dips - Background 67°	45
Figure 14D	1C Dips - Perspective View	46
Figure 15A	1A Widths Footwall - Extracted Data	47
Figure 15B	1A Widths Footwall - Contour	48
Figure 15C	1A Footwall Widths - Perspective View	49
Figure 16A	1B Widths Footwall - Extracted Data	50
Figure 16B	1B Widths Footwall - Contour	51
Figure 16C	1B Footwall Widths - Perspective View	52
Figure 17A	1C Widths Footwall - Extracted Data	53
Figure 17B	1C Widths Footwall - Contour	54
Figure 17C	1C Footwall Widths - Perspective View	55
Figure 18A	1A Widths Hangingwall - Extracted Data	56
Figure 18B	1A Widths Hangingwall - Contour	57
Figure 18C	1A Hangingwall Widths - Perspective View	58
Figure 19A	1B Widths Hangingwall - Extracted Data	59
Figure 19B	1B Widths Hangingwall - Contour	60

Figure No.	Description	
Figure 19C	1B Hangingwall Widths - Perspective View	61
Figure 20A	1C Widths Hangingwall - Extracted Data	62
Figure 20B	1C Widths Hangingwall - Contour	63
Figure 20C	1C Hangingwall Widths - Perspective View	64
Figure 21A	1A Orebody Widths - Extracted Data	65
Figure 21B	1A Orebody Widths - Contour	66
Figure 21C	1A Orebody Widths - Perspective View	67
Figure 22A	1B Orebody Widths - Extracted Data	68
Figure 22B	1B Orebody Widths - Contour	69
Figure 22C	1B Orebody Widths - Perspective View	70
Figure 23A	1C Orebody Widths - Extracted Data	71
Figure 23B	1C Orebody Widths - Contour	72
Figure 23C	1C Orebody Widths - Perspective View	73
Figure 24A	1A Mine Layout - Outline Geometry	74
Figure 24B	1A Mine Layout - Shaded Geometry	75
Figure 24C	1A Mines Layout - Mining Methods	76
Figure 25A	1B Mines Layout - Outline Geometry	77
Figure 25B	1B Mines Layout Shaded Geometry	78
Figure 25C	1B Mines Layout - Mining Methods	79
Figure 26A	1C Mines Layout - Outline Geometry	80
Figure 26B	1C Mines Layout - Shaded Geometry	81
Figure 26C	1C Mines Layout - Mining Methods	82
Figure 27	1C Mines Layout -Rock Failure Positions	83
Figure 28A	1A Hangingwall Width (Inv. Dist. Squared)	84
Figure 28B	1A Hangingwall Width (Inv. Dist. Cubed)	85
Figure 28C	1A Hangingwall Width (Inv. Dist. to Fifth Power)	86
Figure 28D	1A Hangingwall Width (Kriging)	87
Figure 28E	1A Hangingwall Width (Minimum Curvature)	88

List of Tables

Table 1	Rock Mass Quality	89

1.0 SUB-TASK 2 - DEVELOPMENT OF GEOTECHNICAL DATA BASE RETRIEVAL SYSTEM FOR UNDERGROUND MINES

1.1 General

The Sub Task 2 mandate was to develop a user friendly geotechnical database retrieval system to aid in the evaluation of mine stability and design. In particular the system would provide a storage mechanism for pertinent mine data and the spatial characteristics of these data. The system is built on concepts borrowed from ore reserve evaluation where a wealth of experience is gained in the manipulation of spatially dependent data.

This data-base system includes the treatment of pertinent parameters of the hangingwall, footwall, and orebody materials including:

a) rock types, lithology,
b) mechanical properties of various mine rocks,
c) mine geometries,
d) dips,
e) widths,
f) mining methods,

This data-base system (geomechanical) is designed such that data, procured from the field, is easily entered, modified or retrieved and perform analyses. The system is not only applicable to Thompson Mine but also to other underground metal mines.

2.0 HISTORY

Detailed collection for rock mass characterization and on stress conditions was started at Thompson Mine during 1984 as part of a major rock engineering study into crown pillar removal. This data forms the cornerstone to the rock engineering data-base at the mine (Table 1). This data-base was expanded during the current study to further characterize the ore, the immediate hanging wall and the immediate footwall rocks over the entire mine. Although underground data collection is still underway, ample information is available to show mine averages. These averages are used in determining if a specific area will have ground problems.

Surfer, a software program from Golden Software Inc. was chosen for this project. The initial intent of using PC-Mine, a Gemcom software product, was abandoned because of a requirement of 10 Mb's of hardware storage and resultant major changes required.

3.0 OBJECTIVES

The Engineering and Geology departments plan to investigate the use of software grid manipulation or contour overlays to determine structural trends which would aid in predicting potential ground problems.

The program will perform detailed contoured and perspective views on analysis of the geomechanical data collected with respect to rock mass properties and quality, mining conditions, ground support requirements and mining efficiencies.

From historical data we know that hangingwall wall performance are described with dilution or the amount of wall slough that takes place. Contour plots of the mining geometry, and selected geological plots are constructed to determine if any simple relationships exist between wall slough or poor ground conditions and different geological parameters.

3.1 General - Data Collection

Testing of the data retrieval system is now in progress. The first step involved digitizing the mining geometry in the 1-A, 1-B and 1-C zones of the mine. These three zones, are over 50% of the total mining areas, and are selected due to there relatively planar character, and have ease of digitization, and coordinate systems management.

Polygons representing mined out areas are entered into the polygon databases through a program called Digit with a Calcomp 9100 series digitizing tablet Figures 1A, 1B, and 1C. Each polygon digitized represented an individual workplace. For checking purposes the information contained within the polygon database was output to a plotter. Windowing facilities in the program allowed plotting of specific areas for checking.

On completion of the polygon database the grid overlay and grid manipulation systems are checked.

There are three distinct areas of data reduction and compilation. The first area deals with overall mine structure, and orebody geometry; including parameters such as orebody width, orebody dip, hangingwall rock type, hangingwall thickness etc. The second and third areas of interest deal with rock fabric and rock mass quality. Data is acquired from a several sources, including, previous records, core logging, geological sections and plans. A summary sheet, Figure 2, is used to organize this data for ease of input. Data recording is restricted to the orebody and immediate footwall and hangingwall zones.

Information from diamond drilling are recorded and stored on Inco's mainframe data retrieval system. This allows mine wide manipulation of borehole data. A typical output from the system is shown in Figure 3; note the rock quality data contained in the description columns. This data can be individually retrieved and an average estimate of Barton's Q rating acquire (Figure 4). The data manipulation shown in this figure is carried out in either Surfer or a Lotus 123 or equivalent spreadsheet program.

The system is likened to the popular Lotus 1-2-3 spreadsheet program available for the IBM PC. Instead of cell manipulation, which, for example, allows the results in one cell to be multiplied by the result in another, the cells can be replaced by grids. In this manner the result are manipulated.

A flow chart for the retrieval system is given in Figure 5. Pertinent data transferred from mine plans and sections into a spread sheet and converted into more easily manipulated grid fields. This is done through a windowing technique which allows the user to delineate the area within the mine of interest and to specify the size of grid (and hence the detail) required. The resulting grid master files are manipulated by selected parameters.

3.2 Method - Data Collection

A program of material testing is carried out to determine the geotechnical properties of the various rock types that make up the Thompson orebody. Work completed includes a review of previous test data, laboratory testing, field measurements, and examination of exploration drill core.

3.2.1 Joint Sets

Fabric analyses are conducted to determine the geometrical properties of the jointing that occurs throughout the rock mass. Results indicate that joint orientation is similar within each of the major rock types present.

Appropriate values for Jn, Jr, and Ja (explained in a previous section) are selected after examination of drill core, review of the results of detail line surveys and from specific observations underground (Figure 6).

3.2.2 Widths of the Orebody, Footwall, and Hangingwall

From diamond drilling and underground mapping it is observed that biotite schists surrounding the orebody have a strongly developed foliation. Individual foliation planes are highly continuous and represent major planes of weakness. Therefore the thickness of the biotite schists in the hangingwall and footwall is used in the computer program for contouring.

3.2.3 Q - Values

Rock mass classification (Barton et al, 1974) of the major units is carried out and recorded with the PD drilling core log. Values of the rock mass quality (Q) ranged between 0.03 for leached skarns to 11 for biotite gneiss. Five broad classes of rock mass quality are recognized (Figure 7). Engineering properties are expected to be similar within each class. The classes are:

Class I ($6 < Q < 11$) - Biotite gneiss, amphibolite, skarn (hangingwall quartzite and footwall quartzite).

Class II ($3 < Q < 6$) - Hangingwall schists (anisotropic properties).

Class III ($3 < Q < 6$) - Ore Rocks

Class IV ($Q = 1$) - Footwall schist (anisotropic properties) Range $Q = 0.1$ to 3.

Class V ($Q = 0.03$) - Skarn Range $Q = 0.001$ to 0.1.

For the data retrieval method parameters are all mine averages:

Q Hangingwall Schist = RQD/9
Q Footwall Schist = RQD/9(.75)
Q Orebody = RQD/9(1.5)

Values for Q must be calculated for anomalous characteristics. Data collections for this project are restricted to the ore and immediate hanging wall and the immediate footwall rocks.

3.2.4 Mine Geometry

From the geological interpretation of diamond drill information. The data collected includes:

- widths measured horizontally,
- dips measures on section,
- grades (%Ni) of undiluted mineral.

The results suggest, that within cut and fill stopes, conditions are similar regardless of strike or dip, and are likely independent of stress conditions. There are, however, differences in VBM stoping behaviour with respect to hole closure and stope stability. These differences are more dependent on rock mass quality than stress.

In cut and fill stopes there is a time lapse between mining cuts. This allows the gradual redistribution of stress and the rock mass to behave in a relatively ductile manner (i.e. time dependent creep). The immediate stoping activity therefore takes place in a low stress zone. V.B.M. stopes, in contrast, advance rapidly. This may result in a rapid concentration of stress behind the mining face. The rock mass may behave in a more brittle manner and, if stress exceeds strength, shed through progressive failure.

The time related response is inelastic and important to identify whether it takes place within the orebody, the hangingwall and footwall rocks, or includes all strata. Certain factors affect this:

i) As the orebody is comparatively confined, the stope faces and remnant pillars are therefore geometrically capable of developing very high stressed cores.

ii) The main hangingwall and footwall rocks, which consist of gneiss, quartzite and skarn, are significantly stiffer than other rocks.

iii) The immediate footwall and hangingwall schists are the least competent rocks and contain extensive foliation; planes are often infilled with low shear strength material.

It is therefore important that we distinguish the mining methods Figure 8A,8B,and 8C.

3.2.5 Ground Failure

Observations of ground conditions is also very important in the predictions of future problems. With this information we can try to find a correlated common parameter related to these conditions. The 1-C area has five sites which have been recorded and plotted Figure 9.

3.3 Surfer: A Brief Overview

3.3.1 Introduction to Surfer

The purpose of the retrieval system is to provide a way to manipulate data collection from various mining areas. The goal was to gather, store, then retrieve and display the data in a worthwhile fashion.

The collection and storage of the data is fairly simple, though large amounts of memory storage are needed. The problem is to find ways that, once retrieved and assimilated, the data can be outputted in a clear, concise form.

A software package by GEMCOM called PC-Mine was used at the start of the project. This was one commercially available software package that could produce contour plots. This was a total package of programs designed for open pit mine analysis. Through it, one could retrieve the data and then produce contour plots. Problems with this package were its large 10 Mb of computer storage.

Since then, many compact contouring programs have become available commercially. The program chosen for this test study is a package called **Surfer**, published by Golden Software Inc.

Surfer is flexible tool for creating high resolution two dimensional and three dimensional drawings in colour or black and white. The package of programs can be run from floppy disk or from a hard disk. Surfer is much easier to use than PC-Mine; particularly as more input is required to run PC-Mine than Surfer.

3.3.2 Description

The minimum requirements for Surfer are:

- an IBM PC, XT, AT, PS/2 or compatible
- at least 320 kb of RAM
- DOS 2.0 or higher
- at least one double-sided disk drive
- A math co-processor is optional

Surfer consists of six programs. Each program produces output at different stages. These programs are:

GRID - Generates a regular grid from input data
TOPO - Generates contour drawings from regular grids
SURF - Generates 3-D drawings from regular grids
VIEW - Allows viewing of drawings made
PLOT - Produces hardcopies of drawings
UTIL - Various utilities for using on regular grids

A general process flow for a Surfer run is shown on Figure 5.

GRID is the first program in Surfer. It creates a regularly spaced grid from irregularly spaced input data. This data may come from either Lotus 1-2-3 worksheet files, ASCII files set up in columns, or by the user typing the data into the GRID worksheet. Data from GRID is stored in a simple Lotus like worksheet. This worksheet has limits of 26 columns of data, and of 14,000 rows of information. Once in a GRID worksheet, the data is manipulated before regular spaced grids are created.

GRID produces a regularly spaced grid by calculating values at each point where grid lines cross one another. The number of grid lines are specified by the user. The limits on the number of such lines is that the number of X grid lines times the number of Y grid lines must be less that 65,536.

GRID supplies three methods for calculating the values at the intersections of the grid lines. These methods are Inverse Distance, Kriging, and Minimum Curvature. There are advantages and disadvantages to each of these methods. In general, Inverse Distance is the fastest method, but Kriging and Minimum Curvature provide better results in most cases. One problem with both Kriging and Minimum Curvature is developed when input data is not spread out evenly over the entire grid. Areas where data is not present have unpredictable results, and are at best suspect.

TOPO is a program designed to produce contour line maps. It uses regular grids in binary or ASCII formats to create contours. The user has control over all aspects of the drawing, from how the contours are represented, to labelling and posting input data. Output from TOPO can be examination with VIEW, or made into a hardcopy with PLOT.

SURF is a program designed to produce three dimensional surface plots. It uses regular grids in binary or ASCII formats to created these surfaces. The user has control over all aspects of the drawing, from viewing positions, to colour and text. Output from SURF can then be looked at with VIEW, or hardcopies of it makes with PLOT.

VIEW is an interactive viewing facility. It allows the user to look at drawings made with TOPO and SURF, and to make final checks on the drawing before making hardcopies. It ensures that the drawing will fit onto the hardcopies.

PLOT is a program to produce either hardcopies of drawings or to put the drawing into file format that is used with other programs (eg. AutoCAD). PLOT is configured to plot or print to many of todays plotters and printers. It also supports .DXF, .PIC, HPGL, and General Post Script File formats, the drawings can be loaded into other programs. By saving to the other file formats, the user has access to virtually all output devices on the market today.

UTIL is a package of utilities that runs on regular grids created by **SURFER**. This allows the user to perform various operations on grids, like performing volume, produce X-sections, or areas of specific levels, the information is converted to a X, Y, Z file, ASCII to Binary, or Binary to ASCII formats.

Another program used with Surfer is Digit. This is a simple digitizing program that allowed a user to digitize information for use in Surfer. It has the ability to digitize mine information off of a mine drawing. Digit can create point data, for using as input data to create a regular grid. It can also produce line data that can be used as overlays on drawings.

3.3.3 Applications

The following describes a typical session, using Surfer to produce a drawing from input data. Note, the contour line map used in this example. A surface drawing made from SURF could have as easily been used.

The first step is to create input data that GRID can use as input. There are several ways one can do this:

- Input data into a Lotus 1-2-3 worksheet, and use this as input.
- Use an ASCII editor and input data straight to an ASCII file that can be used as input.
- Use Digit to digitize the information from mine drawings, and use the ASCII files that are created

as input.

- Go into the GRID's worksheet and record data as input.

Once input is available, use the GRID program and generate a regular grid. This grid is used with other **SURFER** programs. Various boundary options are defined in the GRID program. The variables are set using the menu options, and supplying keyed in values. Examples of these variables are:

- limits on the grids
- number of grid lines
- methods used to produce the grids.

When options are set, the regular grids are produced and saved in a file. The grid is stored either as a compact binary file, or as an ASCII file, and can be viewed or edited.

The next step is optional. After grids are created, they can be manipulated by other options in GRID. These options are used to smooth grids using spline interpolation and also useful in to smoothing grids that may otherwise be erratic.

A menu driven program called TOPO produces contour line maps of regular grids created from GRID. Some options available are; what contour lines to show, and titles for all the borders used. The user can also overlay information such as original point information over the contour map. This is often useful in the final drawing. Other information that can be overlaid are mine geometry drawings or high-lighting various aspects created by Digit. When all options are set, the information is saved to a file. This file is used with VIEW or PLOT to create hardcopy plots. Complex map drawings are created by layering various parts of the drawing, one layer at a time. In the Figure 12B, four separate layers are needed to produce this drawing.

VIEW is used to check and to ensure the drawings will fit inside the bounds of the paper being used to make a hardcopy on.

The next step is to use PLOT, to produce hardcopies or other file formats for importing into other programs.

When the input data is set up it requires approximately half an hour for a typical section from griding the input data to producing the output.

3.3.4 Benefits and Limitations of Surfer

Surfer is a fairly compact and relatively inexpensive program. If the users device is not supported, Surfer supports many file formats that can be used with other programs that support even more output devices.

There are some limitations to Surfer, the larger the grid or number of input data points, the longer it will take to produce a grid (Figure 10). There should be at least 1 Mb of memory on the storage device to store large grids.

There can also be a memory storage limitation when using **SURFER.** Drawings created by SURF, and TOPO programs may require from 20,000 bytes for a simple drawing to half a megabyte for a complex, multi-

layer drawing. When PLOT is used for printing, it creates an intermediate .OPT file. This is an optimised print file for .OPT files and can be 75,000 bytes to half a mega-byte when using laser printers. Other problems with PLOT occurs when converting drawings to other file formats. One popular format is the .DXF file used in AutoCAD. Complex multi-layer drawings may require 2.5 megabytes of disc storage to save a file. The user should make sure that adequate disc storage space is available before printing or changing file formats.

There are also limitations in the ability to view a section of a drawing. The user can not zoom into any sections of the drawing but, window only sections, between grid lines. This means that the user must find what grid lines enclose the area of interest. The smallest area is the distance from one grid line to the next. (Figure 11).

3.3.5 Conclusions

Surfer is a tool for data retrieval, it is fast and easy to understand. Some of the limitations are a drawback, but the benefits far outweight them.

3.4 Digit Program

3.4.1 Overview of Digit

There are many ways of creating data as input for Surfer. Most involve using a spreadsheet program or an ASCII editor. A drawback of this approach therefore is that all values for the X,Y,Z data must be known.

Digit is a simple digitizing program. One of its strengths is in its use to digitize data in an ASCII format for Surfer. Another strength is that all values of X,Y, and Z do not need to be known in advance. Digit allows the user to digitize a point, and from that point it calculates the X,Y values. Digit will then prompt the user for a Z value. This way, the user needs only to know the Z values of the points he is entering.

The following is the main menu for Digit.

DIGIT -- SIMPLE DIGITIZING

---

0 STOP
1 SET UP DIGITIZER AND PLAN SCALES
2 DIGITIZE POINTS
3 DIGITIZE CONTOUR LINES
4 REWIND POINT AND LINE FILES TO BEGIN AGAIN
5 NORMAL TERMINATION/END

Option 0 Stops program execution. The user will use this option when he has finished a session with Digit.

Option 1 Sets up the mine site. Use this option at the start of each new mine drawing or when moving a drawing on the digitizer. (DIGIT.PN)

Option 2 Digitizes points to create an ASCII file for input to Surfer. (DIGIT.PP)

Option 3 Digitizes lines to create an ASCII file for use by Surfer.

Option 4 Clears the files (DIGIT.PN, DIGIT.PP) where point and line data are stored. Entering new points or lines with above options will append information to the end of these files. This option is useful in helping the user to create multiple files of information from a mine site.

Option 5 Stops the program. Note: With current version of Digit, this option is not working, so use Option 0.

3.4.2 Setting up Digit

A) FILES NEEDED TO SETUP DIGIT

There are several files that Digit uses to run. These files are as follows:

- On the A: drive
  DIG.FIL
  DIGIT.FIL
  DIGIT.EXE (optional)

- On a Hard drive (normally)
  DIGIT.EXE (if not on the A: drive)
  DIGIT.CMM
  DIGIT.MES

DIG.FIL

This file contains the control structure on how Digit runs.

DIGIT.FIL

This file contains the current description of the digitizer in use. Digit comes with several .fil files for popular digitizers. If the file containing the description for a digitizer is available, the user can copy it directly to the Digit.fil file for using. If the file is not among these, the user can easily create one with an ASCII editor.

The standard FILENAME.FIL file contains 7 lines of information. The general format is as follow:

1)	Calcomp Format 1	STRING DESCRIPTION OF DIGITIZER
2)	1	COMMUNICATION PORT IN USE
3)	16	NUMBER OF BUTTONS OR CURSORS
4)	30	MAX NO. OF CHARACTERS IN DIGITIZER STRING
5)	(2x,I1)	POSITION OF BUTTON VALUE IN STRING
6)	(3x,F5.0)	POSITION AND LENGTH OF X-VALUE IN STRING
7)	(8X,F5.0)	POSITION AND LENGTH OF Y-VALUE IN STRING

The above 3 lines (Nos. 5 - 7 inclusive) describe digitizer format (button,x,y).

In the above example, the digitizer is connected to communication port COM 1. The digitizer has 16 buttons, and returns a string of information of at most 30 characters.

When using the Calcomp 9100 digitizer, Format 1, the Data Output Message Format from the cursor is as follows: the number of the button pressed is at the third character in the string returned. The X value starts at the fourth character position and is 5 characters long. The Y value starts at the ninth character position and is also 5 characters long.

To create a .FIL file for a specific digitizer, the user creates an ASCII file with the information in the above format. The format of the string returned by the user's digitizer can be found in the reference/installation manual for the digitizer.

To find the positions of the button, X, and Y values, do the following;

- count from the start of the string to a character before the value. The user places this value before the 'X' in the value X,..) string.
- find the length of the value to return. For the button pressed value, this is the value after the 'I' in the (..X,I value) string. The 'I' means that an integer value is returned.
- for the X and Y position values, this is the value to follow the 'F' in the (..X,F value.0) string. The 'F' means that a real value is returned.

DIGIT.EXE

This is the program file.

DIGIT.CMM

This file contains information on the mine layout limits and changes if the drawing the user is digitizing from is moved, or when using a new mine drawing to digitize.

DIGIT.MES

This file contains the messages and prompts that the Digit program uses to interact with the user.

B) DEFINING THE MINE SITE.

When all files described in a) are in place, the user can run DIGIT to start a new mine site.

To set up the digitizer for a new drawing with DIGIT, the user should do the following steps.

NOTE: Selection of options or responses is done by entering the answer and pressing <return>.

1) Tape the mine drawing onto the digitizer. Make sure that the +X values increase from left to right, and that the +Y values increase from the bottom to the top of the page.

2) With the digitizer on, set the baud rate and communication port of the digitizer with the DOS MODE command. This is done before starting up Digit for the first time, and can be set up in a batch file.

3) To start the program, make sure that the system disc containing the files; DIG.FIL, DIGIT.FIL, and DIGIT.EXE (optionally) are in drive A:. Type DIGIT or A:\DIGIT at the command prompt, depending where the DIGIT.EXE program is located. This will start the program.

4) A message screen of program information will then appear. Press <return> when finished.

5) The screen prompts the user if an audio beep is required when digitized points are entered. Normally choose 'Y' for this option. This is useful as it lets the user know when points are digitized.

6) The main menu now appears on the screen. Select Option 1 to set up the digitizer and the new mines site.

7) A new message screen of tested digitizers appears. Press <return> when finished.

8) The screen prompts the user to digitize four (4) dummy points. This is done to make sure that the digitizer is working and that the format given for it is correct. If there is a problem, follow the advice at the top of the screen. If there are no problems, the program will continue.

9) The message screen will then appear, it explains the preferred orientation of the drawing to the digitizer. Press <return> to continue.

10) DIGIT prompts the user to enter points in this order; Bottom Left, Top Right, Bottom Right, Top left. These points are used to scale the digitizer to the drawing.

11a) DIGIT prompts the user to key coordinate information on the points given in the above step. It also displays information on the scaling of the digitizer to the mine site.

11b) The first prompt is for the X,Y position of the Bottom Left then the Top Right corner. In each case, the user specifies the X then the Y values.

11c) DIGIT displays the scale factor of the digitizer in the X and Y direction.

11d) The next line displays a distortion factor. This accounts for slight distortions in a drawing, possibly caused by photocopiers. This value should be less that 2.5%, for a values larger than 2.5% this calibration should be repeated. If the value is less that 2.5%, the user should choose 'N', and the program will return to the main menu.

At this point, the user can input point or polygon data with the digitizer. The above steps need only be repeated when changing mine drawings, or when the current drawing is moved on the digitizer. Steps 3 to 5 are omitted when the user is already in DIGIT and he wishes to redefine the digitizer.

3.4.3 Digitizing Point Data

Once a mine site is set up as shown in b) above, the user can input point data with Option 2 of the main menu. This allows the user to create an ASCII file containing X, Y, and Z value information to Surfer.

The program DIGIT creates the file DIGIT.PN which contains the point information in the form X, Y, Z. Once all point information for a run or mine site is digitized, the user should copy the file DIGIT.PN to another more meaningful file name. This is a precaution against accidental appending or overwriting this file by the program DIGIT. It is also useful in keeping track of information from various runs.

If the DIGIT.PN file is empty, there is no problem, but if it is not empty, the file is appended to and the user creates more points. To get around this problem, the user should select Option 4 from the main menu. This option will erase the data file, and put the points at the start of the file.

Once in Option 2, the user will input points by using buttons 1, 2, 3, and 4 on the digitizer's cursor.

The following is a list of what the various buttons available to the digitizer are used for by DIGIT's Option 2.

Options for digitizing X,Y point data

BUTTON	USE
1	**X,Y and the previous Z value**
2	**X,Y and a new Z value**
3	**backspace the file one point**
4	**exit to main menu**

Pressing button 1 will create a point at the scaled X, Y position, and will assign the value Z used on the previous point. After pressing the button, the X, Y position, Z value, and point number are displayed.

Pressing button 2 will create a point at the scaled X, Y position on the digitizer. Digit then prompts the user to input a new Z value. After inputting the value, the X, Y positions and Z value are displayed.

NOTE: This is the Z value used when pressing button 1 any time before another button 2 is.

Pressing button 3 will backspace the file by one point. The screen will display a message noting that the file is backspaced.

Pressing button 4 will end input of points in DIGIT. The program then writes out the point data to DIGIT.PN, and returns to the main menu.

There are two general ways of creating point data. They are as follows:

Method 1

1) The user presses button 2, and gives the value for Z when prompted.
2) The user then uses button 1 and digitizes all points on the drawing having the current Z value.
3) Use button 3 if there are any mistakes to correct.
4) If there are more points of different Z values, the user should go back to step 1. Otherwise, the user should press button 4. This saves the point data and returns the user to the main menu.

Method 2

1) The user presses button 2 for every point, and gives the value for Z when prompted.
2) Use button 3 if there are any mistakes to correct.
3) Press button 4 when all points have been digitized. This saves the point data file and returns the user to the main menu.

Creation of multiple point files from one mine site is fairly easy. The user creates one point data file DIGIT.PN. The user exits DIGIT, and copies DIGIT.PN to another file. The user will re-enter DIGIT, and select Option 4 from the main menu. This will clear the DIGIT.PN file. The user will create another point file. Repeating the above steps, the user can create many point files from the one mine site.

Do the following to create multiple point files in which X and Y values stay constant and Z values change. After creating the DIGIT.PN file, copy the file to as many files as required. Using an editor, change the Z values. This is much easier than re-digitizing all the data again, the X and Y values remain the same. Re-digitizing does not guarantee this.

3.4.4 Digitizing Line Data

When the information is set in b) above, polygon contour data can be inputed with Option 3 of the main menu. This allows the user to create an ASCII file of polygon contour data, and allows layering of polygon line drawings made by **SURFER**.

There are two types of polygons: opened and closed. Opened polygons start and end at different points. Closed polygons start and end at the same point.

The program DIGIT creates the file DIGIT.PP and contains the polygon information in the following form:

```
NPOINTS , DUMMY
X  Y
X  Y
 etc.

NPOINTS , DUMMY
X  Y
X  Y
```

etc.
etc.

Where:

NPOINTS	is the number of points in the polygon
DUMMY	is a dummy value. When using this as a drawing file in Surfer, this value is not important. The value should be a 0 or 1.
X,Y	are the coordinates of a point on the polygon. Polygons are drawn as a group of lines from one point to the next.

When all the polygon information for a run is digitized, copy the file DIGIT.PP to another file. This is a precaution against possible appending or overwriting by DIGIT. It is also useful in keeping track of information from various runs.

To input polygon data, select Option 3 from the DIGIT main menu. Lines are appended to the end of the DIGIT.PP file.

If the DIGIT.PP file is empty, there is no problem, but, if the file is not empty, and the user will add more polygons to this file. To get around this, select Option 4 from the main menu. This option will erase the old data in the file, and put the subsequent polygons at the start of the file.

In Option 3, DIGIT prompts to digitize more polygons, answer 'Y' to create more, or 'N' for no more. The user will then input polygons by using buttons 1,2,3, and 4 on the digitizer's cursor.

The following is a list of what the various buttons available to the digitizer are used for by Digit's Option 3.

Options for digitizing contours

BUTTON	USE
1	**First and subsequent points along the contour**
2	**Last point of an OPEN contour (or return to main menu)**
3	**Last point of a CLOSED contour (or return to main menu)**
4	**Erase previous point digitized**

Pressing button 1 will create a point at the scaled X,Y position. This point is either the first point on a polygon, or some point along the line. After pressing the button, the program will display 'POINT', point number, X,Y position, and the button pushed. The point number displayed is correct, even if backspacing has occurred.

Pressing button 2 creates the last point on the current polygon at the scaled X,Y position and makes the line an open polygon. The program will then save the line out to the DIGIT.PP file, and prompt the user if he wants to create more polygons.

Pressing button 3 creates the last point on the current polygon at the scaled X,Y position and makes the

line a closed polygon. The program will then save the line out to the DIGIT.PP file, and prompt the user if he wants to create more lines.

Pressing button 4 will backspace the polygon by one point. After pressing the button, the program will correct the current point number on the line. The program then pauses for the user to press <return> to continue with the current polygon. This option is useful for correcting mistakes made when inputting the points for the polygon data.

The general way to create a polygon data file is to use button 1 to start the line and to put subsequent points on the line. To end the line, use button 2 or 3. To correct any errors, use button 4. Finally, to return to the main menu, end the current line and answer 'N' to create more polygons prompt.

Creation of multiple polygon files from one mine site is fairly easy. Create a one line data DIGIT.PP file. Exits DIGIT, and copy DIGIT.PP to another file. Re-enter DIGIT and select Option 4 from the main menu. This will clear the DIGIT.PP file, now create another polygon data file. Repeating the above two steps, to create many polygon data files from the one mine site.

4.0 RESULTS

The results that follow are output created by Surfer. These results are specific to the mine site at INCO Ltd., Manitoba Division, Thompson Manitoba. Note, there are no outputs from other previous programs used.

Three main orebodies are used in the test study of the Surfer program. These orebodies are the 1A, 1B, and 1C orebodies. Coordinates collected are on a local coordinate system using feet as the unit of measure. In this section of the report, values of distances will be in standard units, with the metric equivalent in brackets.

A point is specified to be "X" North and "Y" East, and all measurements are in feet from that point. The elevation of the Thompson site is 700 ft. (213.36 m) above sea level, and the local coordinate of the surface is 10,700 ft. (3261.36 m). There is an overlap of the orebodies so trends are noted from one orebody to another.

4.1 Dip Results

Figures 12A to 14D are results of Surfer's analysis of dip data collections at Thompson.

All contour line figures were created using the inverse distance squared method. Contour line values range from 35° to 80°.

- Input dip data values range from 30° to 90°:

  i) 1A orebody - Figure 12A
  ii) 1B orebody - Figure 13A
  iii) 1C orebody - Figure 14A

- Contour lines for dip data with no background value are:

  i) 1A orebody - Figure 12B
  ii) 1B orebody - Figure 13B
  iii) 1C orebody - Figure 14B

- The background dip values are the averages of the dips for each area.

- Contour lines for dip data with a background value are;

  i) 1A orebody - background dip is 67.7°- Figure 12C
  ii) 1B orebody - background dip is 60.6°- Figure 13C
  iii) 1C orebody - background dip is 67° - Figure 14C

- 3-dimensional perspective plots of the dip data are;

  i) 1A orebody - background dip is 67.7°- Figure 12D
  ii) 1B orebody - background dip is 60.6°- Figure 13D
  iii) 1C orebody - background dip is 67° - Figure 14D

4.2 Width Results

The thickness of the biotite schists in the hangingwall and footwall were used for contouring.

4.2.1 Footwall Width Results

Contouring was done on the biotite schist widths on the footwall rock types at the Thompson mine. Surfer's analyzed results are shown in Figures 15A to 17C.

For all contour line figures, the inverse distance squared method of producing a regular base grid are used.

- Input data values for the footwall widths range from 0 ft. (0 m) to 20 ft. (6.096 m) they are shown in;

  i) 1A orebody - Figure 15A
  ii) 1B orebody - Figure 16A
  iii) 1C orebody - Figure 17A

- Contour line values range from 0 ft. (0 m) to 20 ft. (6.096 m).

  i) 1A orebody - Figure 15B
  ii) 1B orebody - Figure 16B
  iii) 1C orebody - Figure 17B

- 3-dimensional perspective plots of the footwall data are;

    i) 1A orebody - Figure 15C
    ii) 1B orebody - Figure 16C
    iii) 1C orebody - Figure 17C

4.2.2 Hangingwall Width Results

Contouring was done on the biotite schist widths on the hangingwall rock types at the Thompson mine. Surfer's analyzed results are shown in Figures 18A to 20C.

For all contour line figures, the inverse distance squared method of producing a regular base grid was used.

- Input data values for the hangingwall widths range from 0 ft. (0 m) to 20 ft.(6.096 m) they are shown in;

    i) 1A orebody - Figure 18A
    ii) 1B orebody - Figure 19A
    iii) 1C orebody - Figure 20A

- Contour line values range from 0 ft. (0 m) to 20 ft. (6.096 m).

    i) 1A orebody - Figure 18B
    ii) 1B orebody - Figure 19B
    iii) 1C orebody - Figure 20B

- 3-dimensional perspective plots of the hangingwall data are;

    i) 1A orebody - Figure 18C
    ii) 1B orebody - Figure 19C
    iii) 1C orebody - Figure 20C

4.2.3 Ore Width Results

Contouring was done on the orebody widths these are measured horizontally. Surfer's analyzed results are shown in Figures 21A to 23C.

For all contour line figures, the inverse distance squared method of producing a regular base grid are used.

- Input data values for the orebody widths range from 0 ft. (0 m) to 75 ft. (23 m) in the 1A orebody, in the 1B, and 1C the widths range for 0 ft. (0 m) to 170 ft (50 m). The data values are plotted in figures;

    i) 1A orebody - Figure 21A

ii) 1B orebody - Figure 22A
iii) 1C orebody - Figure 23A

- Contour line for orebody widths are shown in figures;

  i) 1A orebody - Figure 21B
  ii) 1B orebody - Figure 22B
  iii) 1C orebody - Figure 23B

- 3-dimensional perspective plots of the orebody with data are shown if figures;

  i) 1A orebody - Figure 21C
  ii) 1B orebody - Figure 22C
  iii) 1C orebody - Figure 23C

4.3 Mine Geometry Results

Figures 24A to 26C are drawings of the mine geometry of the Thompson site. The drawings show the outline of mined out areas in the 1A, 1B, and 1C orebodies.

4.3.1 Orebody Mine Geometry Results

- The mine geometry polygons are shown in;
  (There are two copies included: one on normal paper, one on transparency.)

  i) 1A orebody - Figure 24A
  ii) 1B orebody - Figure 25A
  iii) 1C orebody - Figure 26A

- The mine geometry polygons with shading are shown in;
  These drawings are made with Surfer and edited in ACAD to add in the shading.

  i) 1A orebody - Figure 24B
  ii) 1B orebody - Figure 25B
  iii) 1C orebody - Figure 26B

- Different mining methods used to extract the ore are shown on the mining geometry drawing; These drawings are made with Surfer and edited in ACAD to add in the shading.

  i) 1A orebody - Figure 24C
  ii) 1B orebody - Figure 25C
  iii) 1C orebody - Figure 26C

- Areas of record ground failures after mining are shown in Figure 27. This drawing are made with Surfer and edited in ACAD to add in the failure locations.

4.4 Results Comparing Methods of Producing Regular Grids

Figures 28A to 28E are results of various methods used by Surfer to produce base grids.

Surfer employs three methods to produce base grids. These methods are:

1) **Inverse Distance**
2) **Kriging**
3) **Minimum Curvature**

The figures are from the 1A Orebody, using hangingwall width values.

The figures are:

- Inverse Distance Squared is shown in Figure 28A.
- Inverse Distance Cubed is shown in Figure 28B.
- Inverse Distance to the power of 5 is shown in Figure 28C.
- Kriging is shown in Figure 28D.
- Minimum Curvature is shown in Figure 28E.

Tests runs of collected data will be tried and a selection of the best method be made.

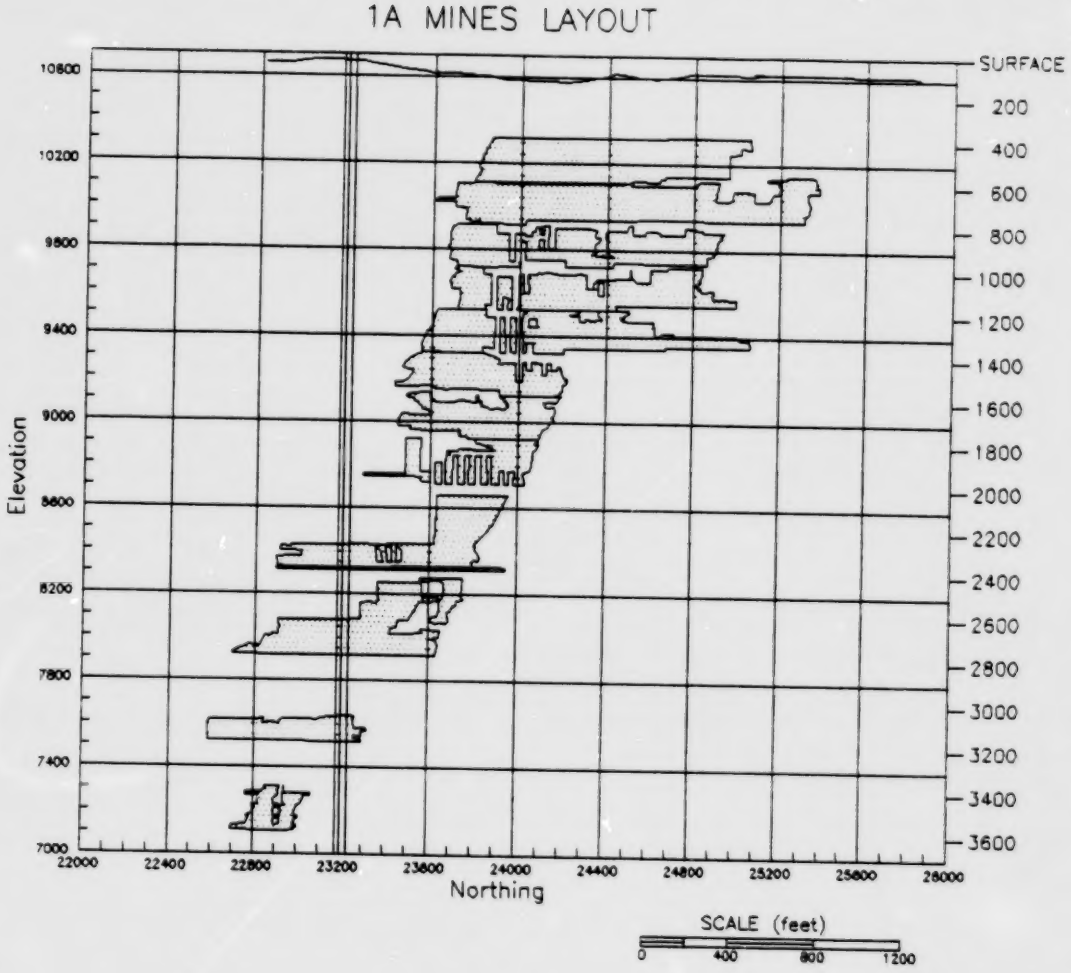

1A MINES LAYOUT
SURFACE
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
3000
3200
3400
3600
10600
10200
9800
9400
9000
8600
8200
7800
7400
7000
Elevation
22000
22400
22800
23200
23600
24000
24400
24800
25200
25600
26000
Northing
SCALE (feet)
0
400
800
1200

FIGURE 1A

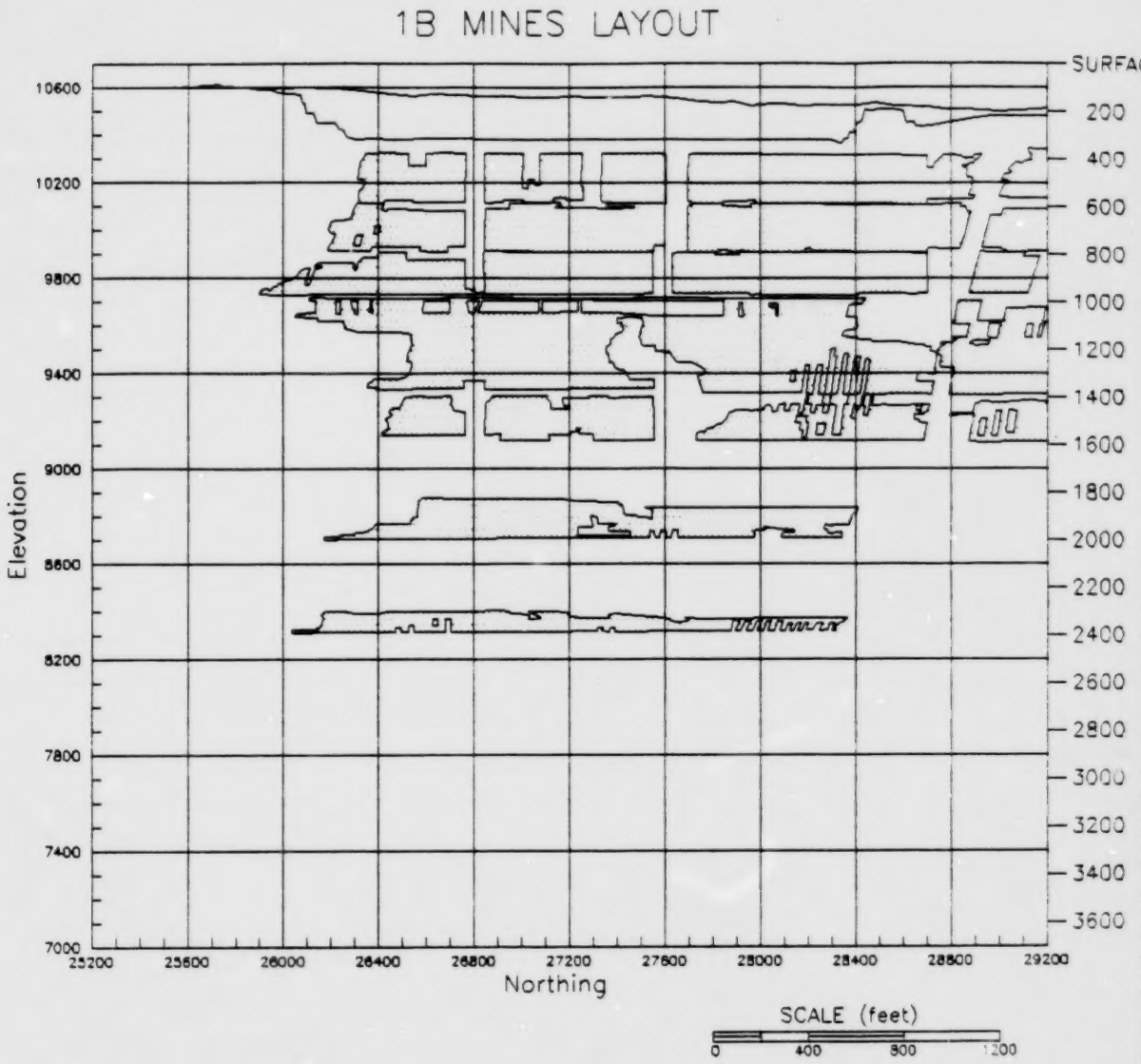

1B MINES LAYOUT
Elevation
10600
10200
9800
9400
9000
8600
8200
7800
7400
7000
SURFACE
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
3000
3200
3400
3600
25200
25600
26000
26400
26800
27200
27600
28000
28400
28800
29200
Northing
SCALE (feet)
0
400
800
1200

FIGURE 1B

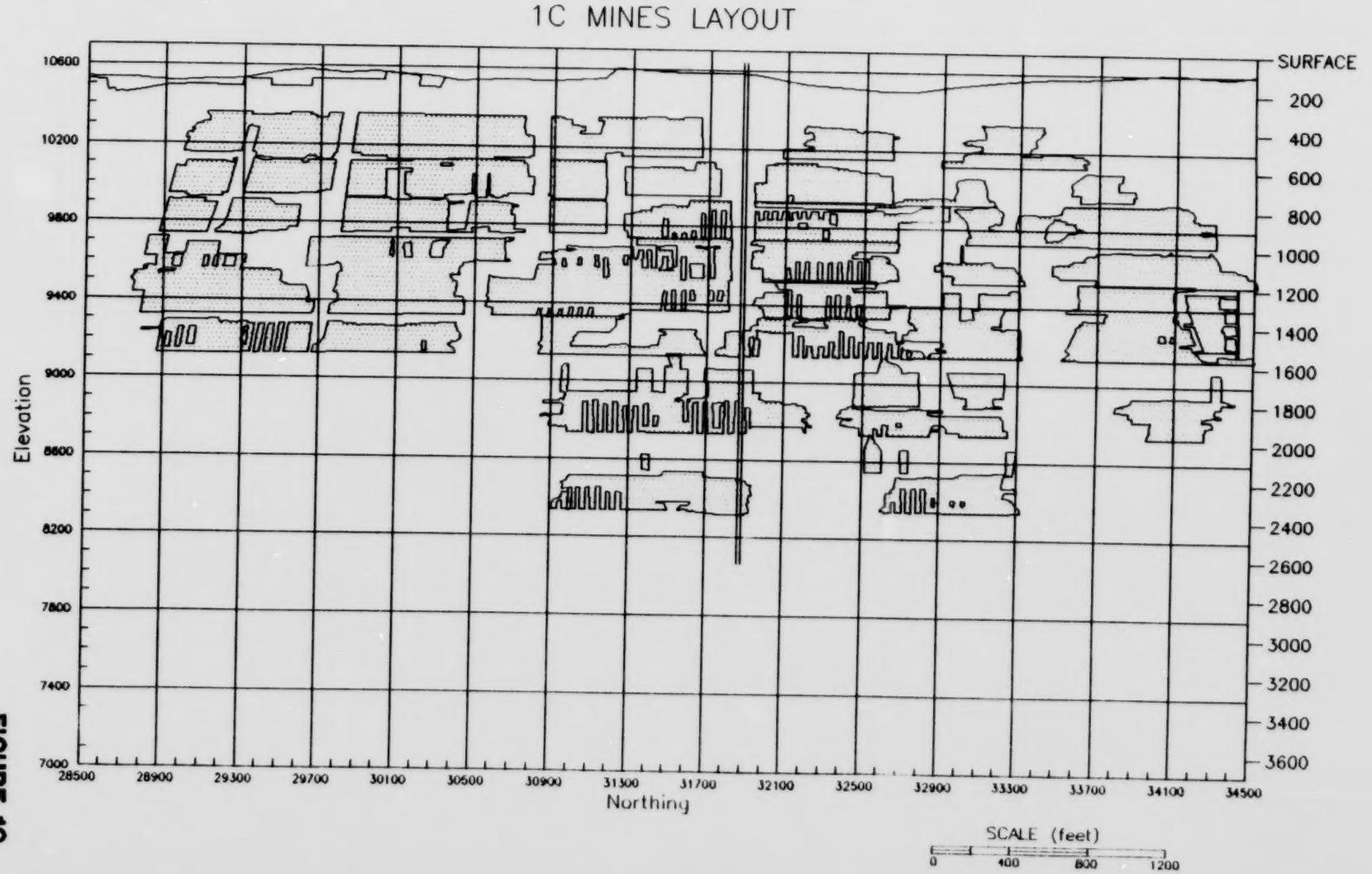

1C MINES LAYOUT
Elevation
10600
10200
9800
9400
9000
8600
8200
7800
7400
7000
SURFACE
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
3000
3200
3400
3600
28500
28900
29300
29700
30100
30500
30900
31300
31700
32100
32500
32900
33300
33700
34100
34500
Northing
SCALE (feet)
0
400
800
1200

FIGURE 1C

CANMET - DESIGN INPUT DATA

SECTION #: _____

SHEET ___ OF _____
DATE: _____
NAME: _____

BH#	ELEV.	ZONE	ROCK TYPE			WIDTH			RQD.			JOINT ALTERATION			Q			GRADE % NI	DIP	SCHED.	INDUCED STRESS (MPa)		MINE METH.	MAJOR STRUCTURES COMMENTS
			FW	HW	ORE	FW	HW	ORE	FW	HW	ORE	FW	HW	ORE	FW	HW	ORE				VERT.	HORIZ.		

AW5008 BOREHOLE RECORD DATE PROCESSED 06/13/88

ASSAYS CHK'D.....

BOREHOLE	MINE	NUMBER	LEVEL	DEPTH	AZIMUTH	DIP	CO ORD	LATITUDE	DEPARTURE	ELEVATION	STARTED	COMPLETED	DATE..... CHKED	MRGD
74502-0	THOMPSON	63	2800.	90.	90 0	62 0	1	N 23250.	E 8824.	8181.	3 6 87	3 11 87	1	1

TROPARI TESTS

DEPTH	AZIMUTH	DIP	DEPTH	AZIMUTH	DIP	DEPTH	AZIMUTH	DIP	DEPTH	AZIMUTH	DIP
10	90 0	+62 0	85	90 0	+63 30	0	0 0	0 0 0	0	0 0	0 0 0

LOGGED BY R SMITH,EXT INCO,30 ST,CHECKED BY N L ECKSTRAND

DEPTH	LENGTH	SAMPLE	MINERALIZATION EST.G	CU	NI	CO	CU+NI	S	SG	TPM	ORE	ROCK	DESCRIPTION	PROGRESSIVE TOTALS CU	NI	CU+NI
0.0	0.0												COLLAR			
29.5	29.5											IF	DK GY GRN TO BLK,QTZ,AMPB,GAR, FG,OCC PK			
													CG PEG BNDS,BNDD,45-55			
49.0	19.5												R4,JN2,JR2,JA0,RQD 055			
												SCH	BIOT,SLCS,OCC MG WHT PEG INCS, BCKY,BNDD			
													55-50			
54.5	5.5	600038	3.50	0.21	2.21	0.04	2.42	0.0	3.41			SUMX	R3,JN2,JR2,JA0,RQD 025 50%,FO PN PY,2XB2,FG,SCH INCS, BLKY	1.2	12.2	13.3
62.4	7.9	600039	* 0.40	0.16	1.04	0.02	1.20	0.0	3.18			MSCH	R3,JN2,JR5,JA0,RQD 010 5%,SULF STRS,FG,BLKY,BNDD,45-3 5	2.4	20.4	22.8
74.0	11.6	600040	0.20	0.06	0.33	0.01	0.39	0.0	3.04			SCH	R3,JN3,JR2,JA0,RQD 015 BIOT,GY,FG,BLKY,BNDD,35-45-40	3.1	24.2	27.3
79.0	5.0	600041	2.80	0.08	2.61	0.05	2.69	0.0	3.49			SUMX	R3,JN2,JR2,JA0,RQD 015 40%,FO PN PY,2XA2,FG,NMKS SCH INCS	3.5	37.2	40.8
90.0	11.0											SCH	R3,JN2,JR5,JA0,RQD 050 BIOT,GY,FG,BLKY,BNDD,20-25			
													R3,JN4,JR2,JA2,RQD 015 FOOT OF HOLE			

FIGURE 3

BHRTRP40 ROCK MASS QUALITY 88-06-1

BOREHOLE 745020 INTERVAL FROM: TO 9999.9

DEPTH	LENGTH	ROCK	#RQD	#JN	#JR	#JA	#JW	#SRF	#Q
				***	INTERVAL	START	***		
29.5	29.5	IF	55	9	1.5	0.75	1.00	1.0	12
49.0	19.5	SCH	25	9	1.5	0.75	1.00	1.0	5
54.5	5.5		10	9	3.0	0.75	1.00	1.0	4
62.4	7.9		15	9	1.5	0.75	1.00	1.0	3
74.0	11.6	SCH	15	9	1.5	0.75	1.00	1.0	3
79.0	5.0		50	9	3.0	0.75	1.00	1.0	22
90.0	11.0	SCH	15	9	1.5	2.00	1.00	1.0	1
				***	INTERVAL	END	***		
AVERAGE	90.0		31.9						7.3
90.0	*****END OF BOREHOLE								

FIGURE 4

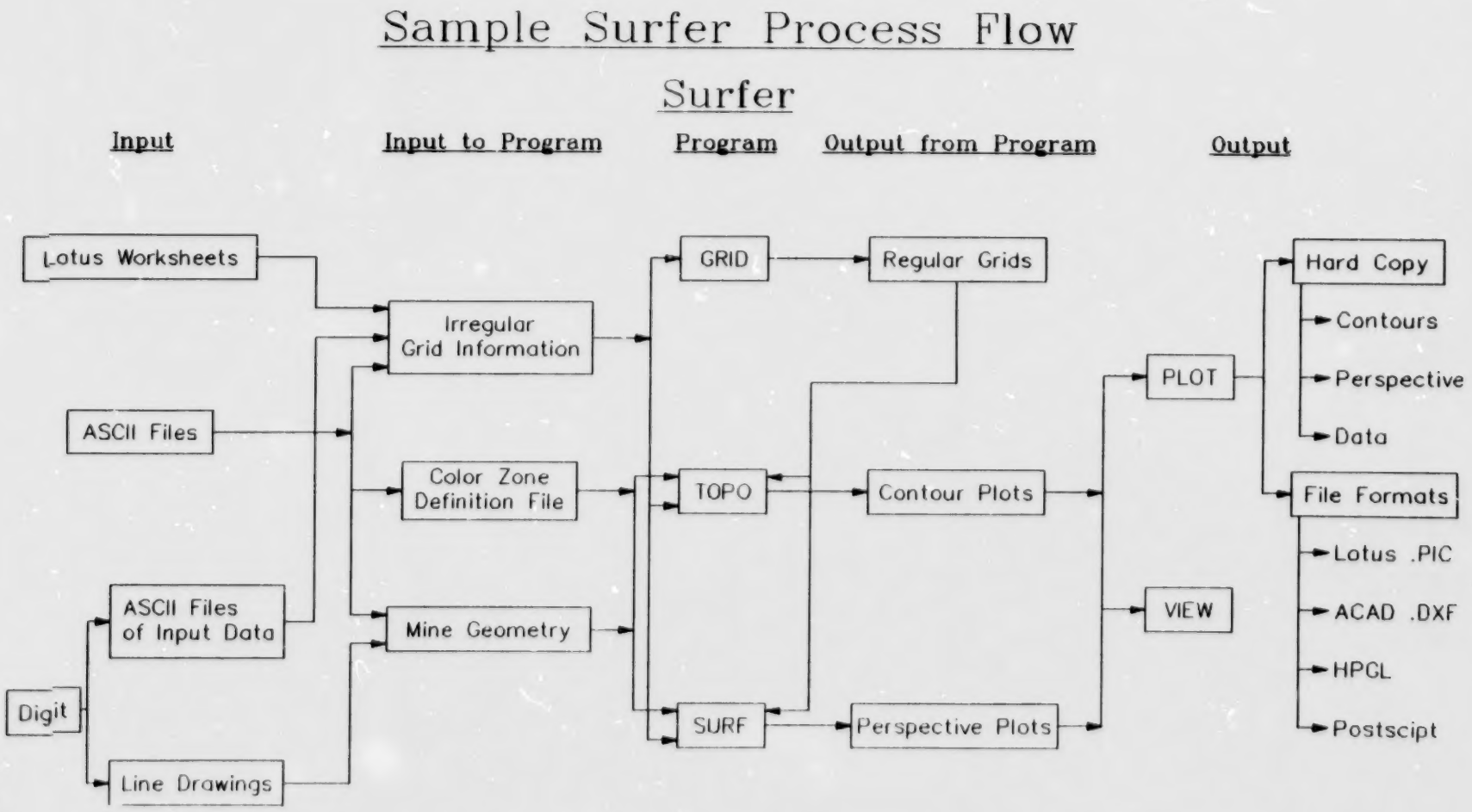

Sample Surfer Process Flow
Surfer
Input
Input to Program
Program
Output from Program
Output
Lotus Worksheets
ASCII Files
ASCII Files of Input Data
Digit
Line Drawings
Irregular Grid Information
Color Zone Definition File
Mine Geometry
GRID
TOPO
SURF
Regular Grids
Contour Plots
Perspective Plots
PLOT
VIEW
Hard Copy
Contours
Perspective
Data
File Formats
Lotus .PIC
ACAD .DXF
HPGL
Postscipt

FIGURE 5

ROCK MASS CLASSIFICATION DATA SHEET

LOCATION: Level _____ Face _____ Distance _____	DATE

Rock Type	Strength	Sketch	Q =
			MRMR =
			Avg. Vol. =
			Shape
			RQD

Joint Data	Set 1	Set 2	Set 3	Set 4
Dip Direct/Dip Angle				
Average Spacing (ft)				
Estimated No. of Joints/m^3				

JOINT ALTERNATION NUMBER (Ja)

Description of gouge	Joint alteration number (Ja) for joint separation (mm)		
	<1.0[1]	1.0-5.0[2]	>5.0[3]
Tightly healed, hard, nonsoftening impermeable filling	0.75	-	-
Unaltered joint walls, surface staining only	1.0	-	-
Slightly altered, non-softening, non-cohesive rock mineral or crushed rock filling	2.0	4.0	6.0
Non-softening, slightly clayey non-cohesive filling	3.0	6.0	10.0
Softening or low friction clay mineral coatings and small quantities of swelling clays	4.0	8.0[5]	13.0
Shattered or micro-shattered (swelling) clay gouge, with or without crushed rock	5.0	10.0[4]	18.0

JOINT ROUGHNESS NUMBER (Jr)

Joint Separation	Condition of Joint	Joint Roughness Number (Jr)
Joints/fissures tight or losing during excavation	Discontinuous joint/fissures	4.0
	Rough or irregular, undulating	3.0
	Smooth undulating	2.0
	Rough or irregular, planar	1.5
	Smooth planar	1.0
	Slickensided planar	0.5
Joints/fissures open and remain open during excavation	Joints/fissures either open or containing relatively soft gouge or sufficient thickness to prevent joint/fissure wall contact upon excavation.	1.0
	Shattered or micro-shattered clays	1.0

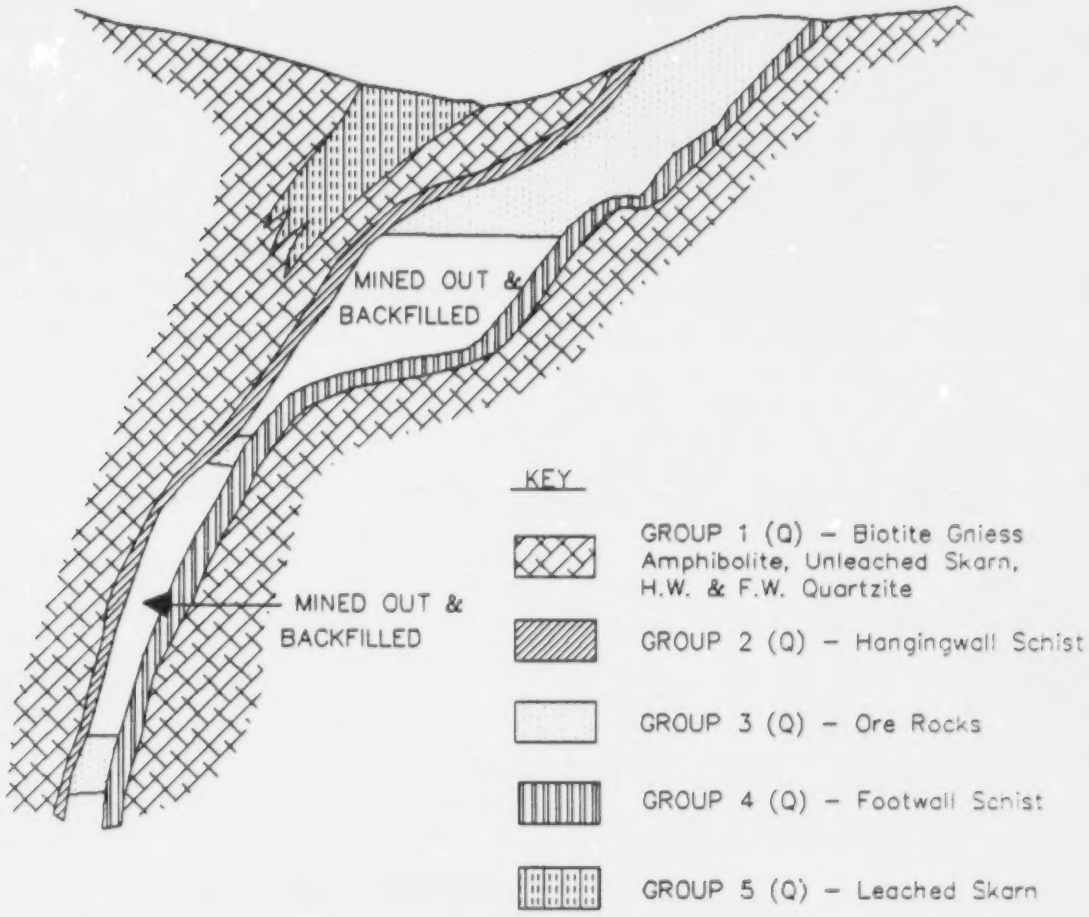
JOINT SET NUMBER (Jn)

Number of joint sets	Joint set number (Jn)
Intact, no or few joint/fissures	0.5 - 1.0
One joint/fissure set	2
One joint/fissure set plus random	3
Two joint/fissure sets	4
Two joint/fissure sets plus random	6
Three joint/fissure sets	9
Three joint/fissure sets plus random	12
Four or more joint/fissure sets, random, heavily jointed, sugar cube, etc.	15
Multiple joint/fissure sets (crushed rock, earth-like)	20

STRESS REDUCTION FACTOR (SRF)

Weakness zones intersecting pillar.	10.0
Multiple occurrences of weakness zones containing clay or chemically disintegrated rock, very loose surrounding rock (any depth).	2.5
Single weakness zones containing clay, or chemically disintegrated rock.	2.5
Multiple shear zones in competent rock (clay free), loose surrounding rock.	7.5
Single shear zones in competent rock (clay free).	2.5
Loose open joints, heavily jointed or 'sugar cube'.	5.0

FIGURE 6

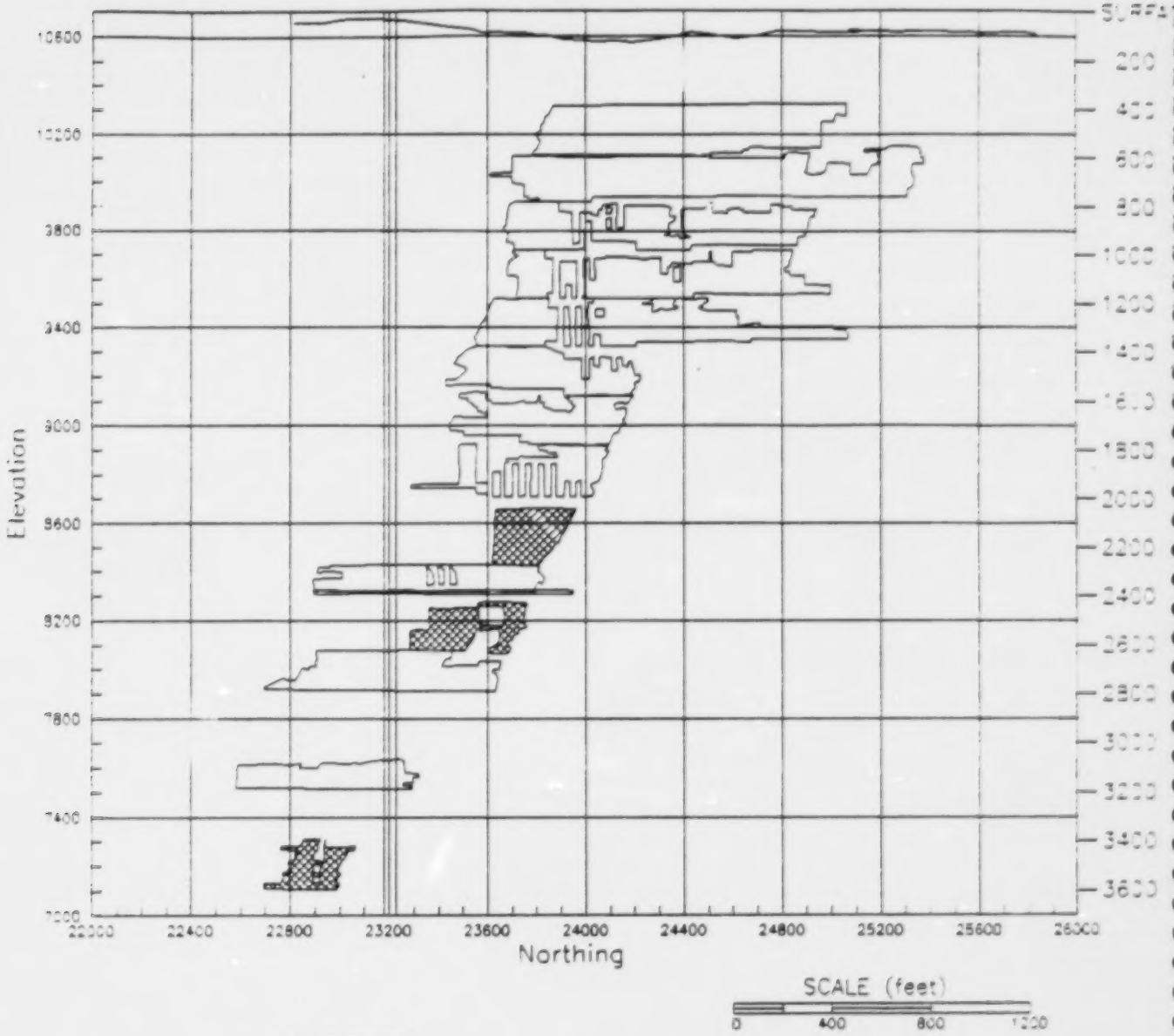


IDEALIZED X-SECTION SHOWING ROCK MASS QUALITY DOMAINS

FIGURE 7

Mining Methods

1A MINES LAYOUT



LEGEND

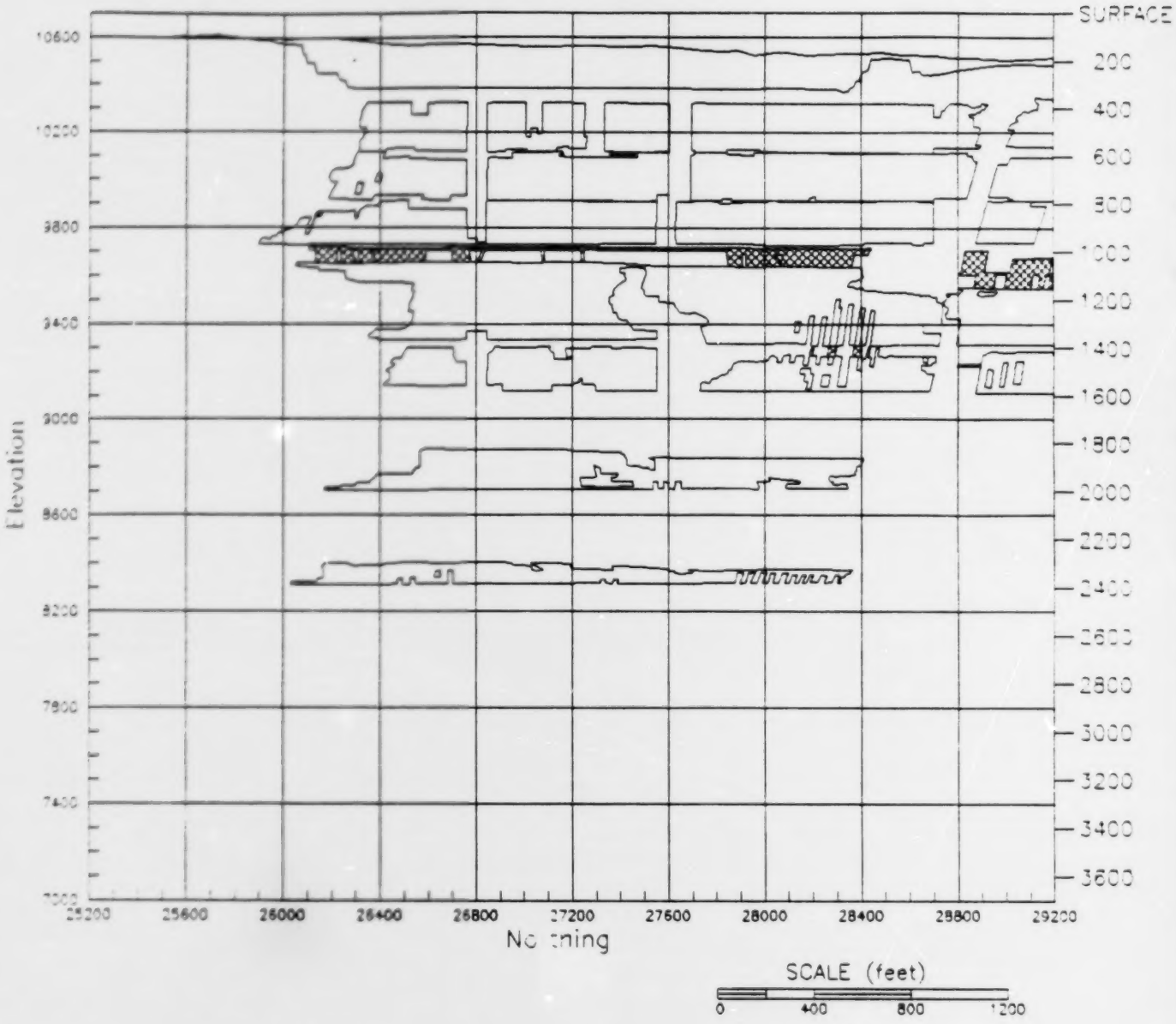
Vertical Block Mining

Cut and Fill Mining

FIGURE 8A

Mining Methods

1B MINES LAYOUT



LEGEND

Vertical Block Mining

Cut and Fill Mining

FIGURE 8B

Mining Methods

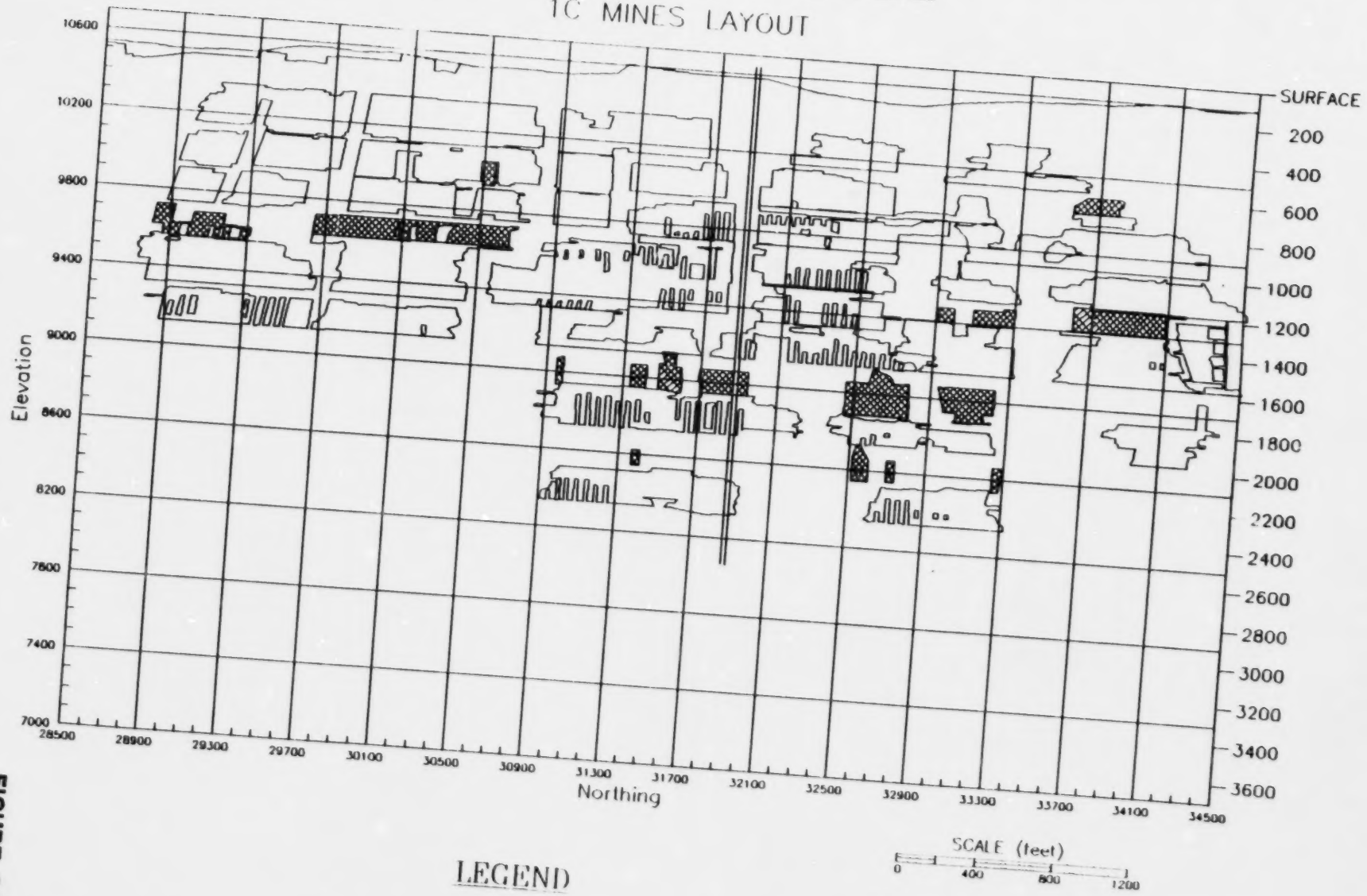
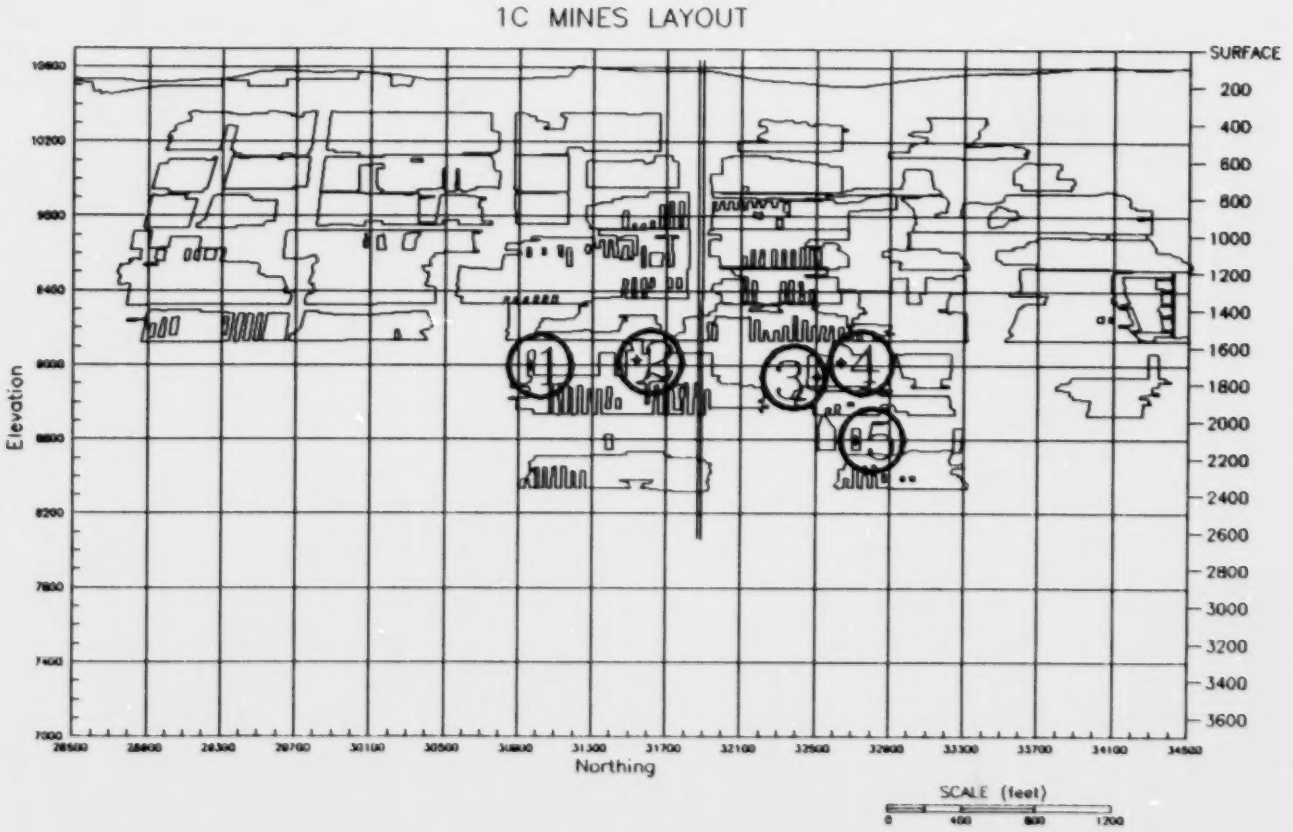


FIGURE 8C

Rock Failure Positions.



Position and Type of Failure

(1) 31,500 North, 1800 Level Stope. Block 2 Mechanical Anchor.

(2) 31,500 North, 1800 Level Stope. Block 8 Mechanical Anchor.

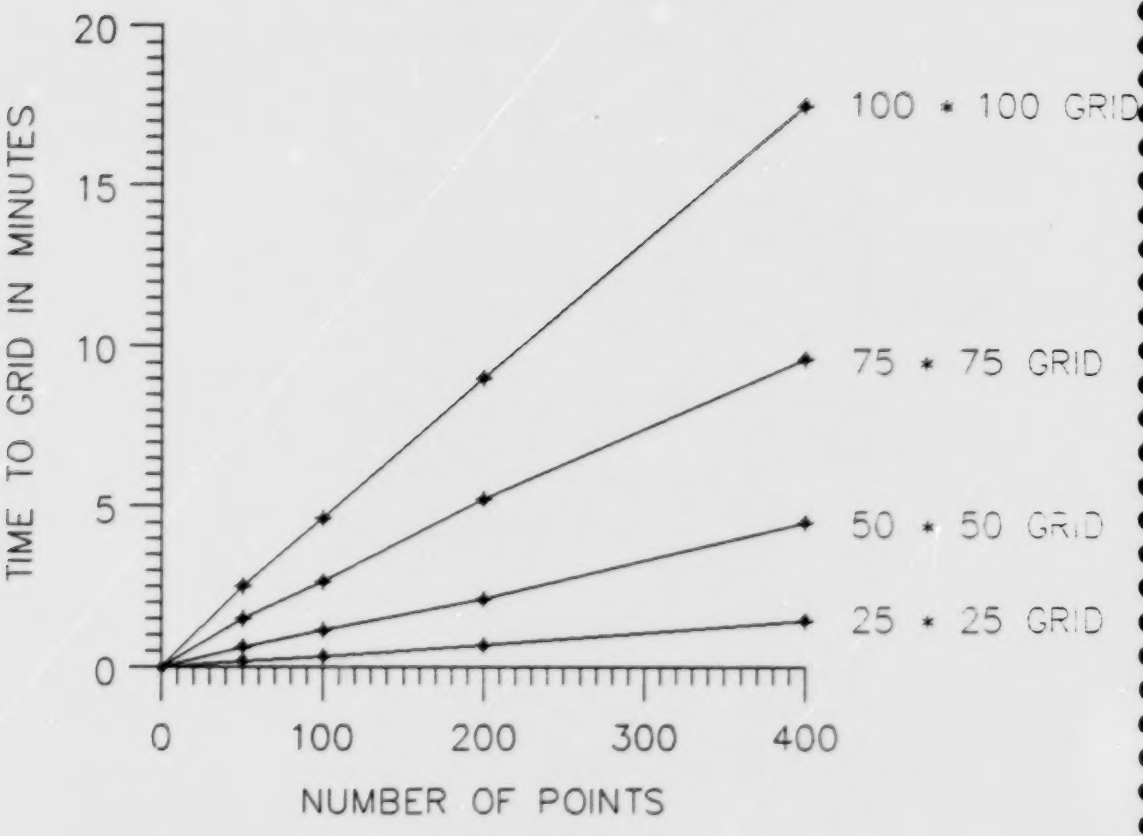
(3) 33,000 North, 1800 Level Stope. Block 6 Mechanical Anchor.

(4) 33,000 North, 1800 Level Stope. Block 8 Mechanical Anchor.

(5) 33,000 North, 2203 Level Stope. Block 1 Mechanical Anchor.

FIGURE 9

Time to Create a Grid



NOTE: The above graph illustrates different timing tests for creating a grid using Inverse Distance Squared on an IBM PC-AT with an 80287 math co-processor and with a hard disk.

FIGURE 10

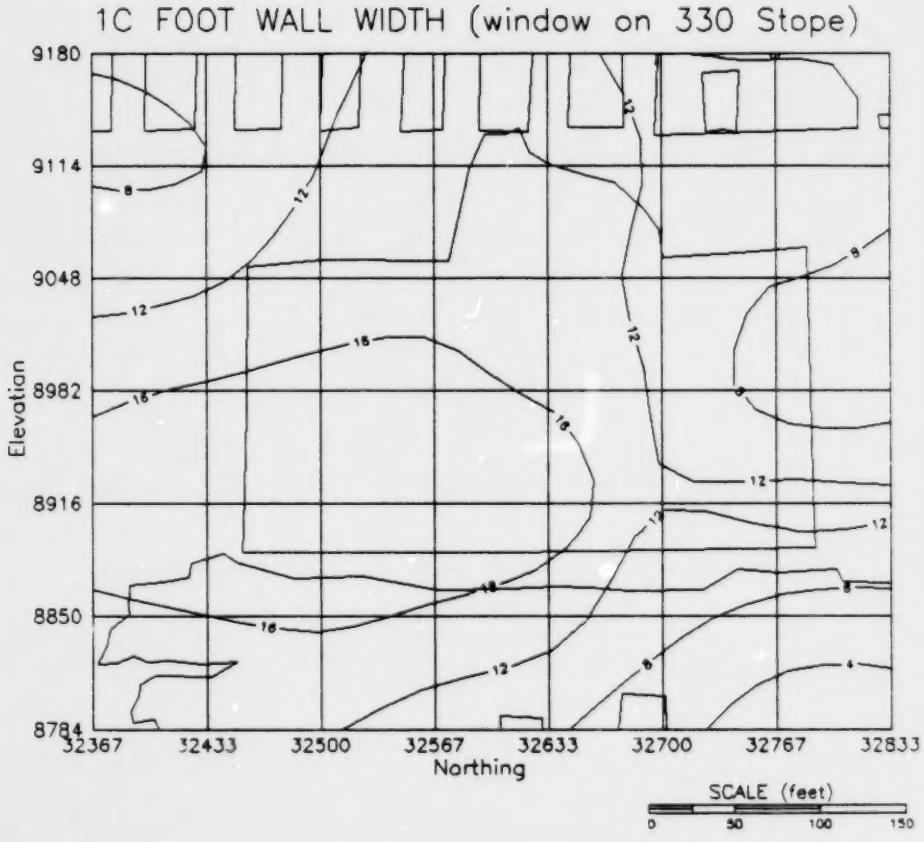

1C FOOT WALL WIDTH (window on 330 Stope)
9180
9114
9048
8982
8916
8850
8784
Elevation
32367
32433
32500
32567
32633
32700
32767
32833
Northing
SCALE (feet)
0
50
100
150

FIGURE 11

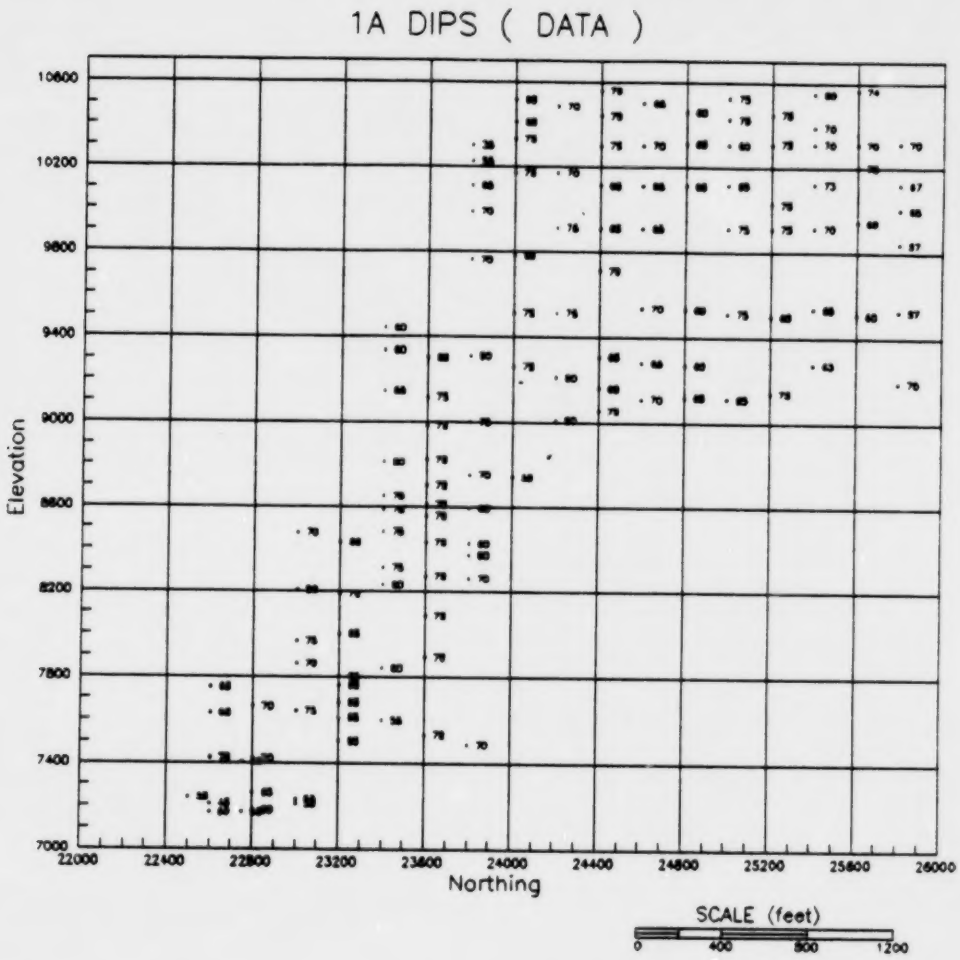

1A DIPS (DATA)
Elevation
10600
10200
9800
9400
9000
8600
8200
7800
7400
7000
22000
22400
22800
23200
23600
24000
24400
24800
25200
25600
26000
Northing
SCALE (feet)
0
400
800
1200

FIGURE 12A

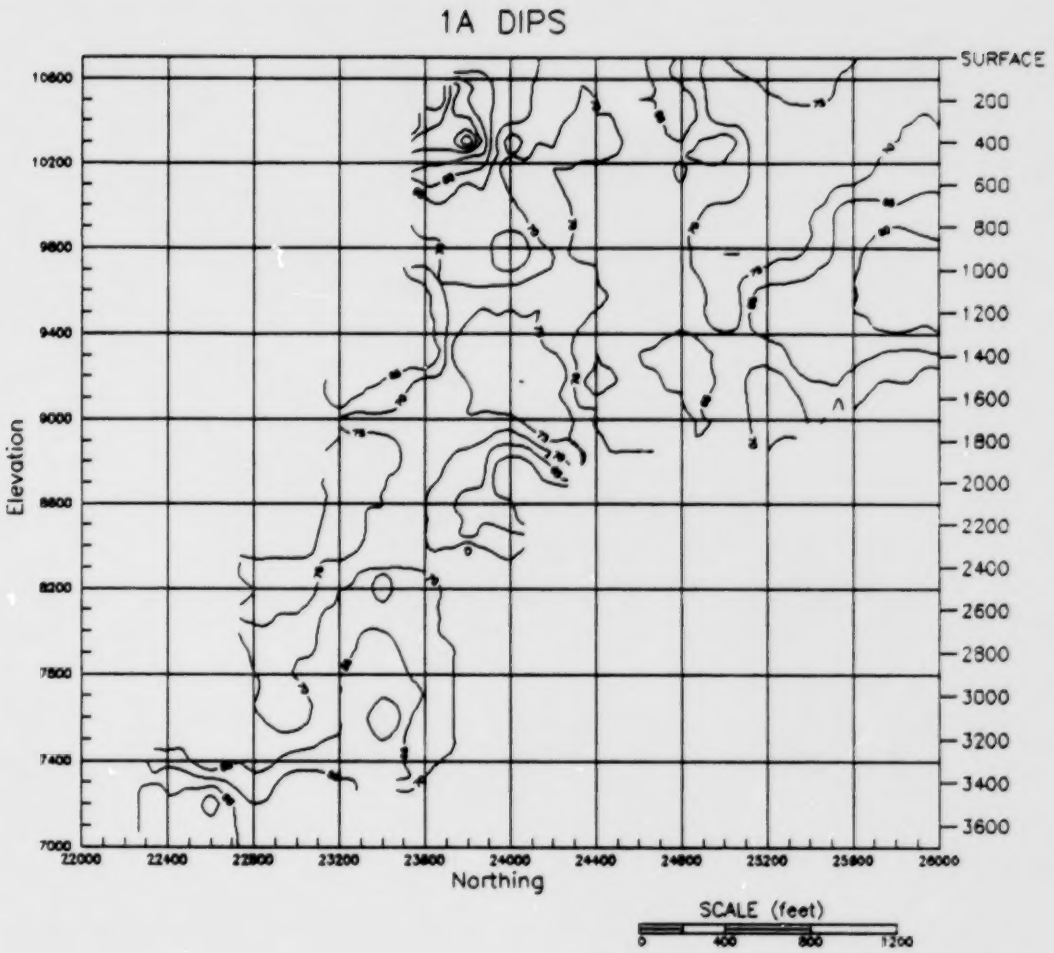

1A DIPS
SURFACE
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
3000
3200
3400
3600
10600
10200
9800
9400
9000
8600
8200
7800
7400
7000
Elevation
22000
22400
22800
23200
23600
24000
24400
24800
25200
25600
26000
Northing
SCALE (feet)
0
400
800
1200

FIGURE 12B

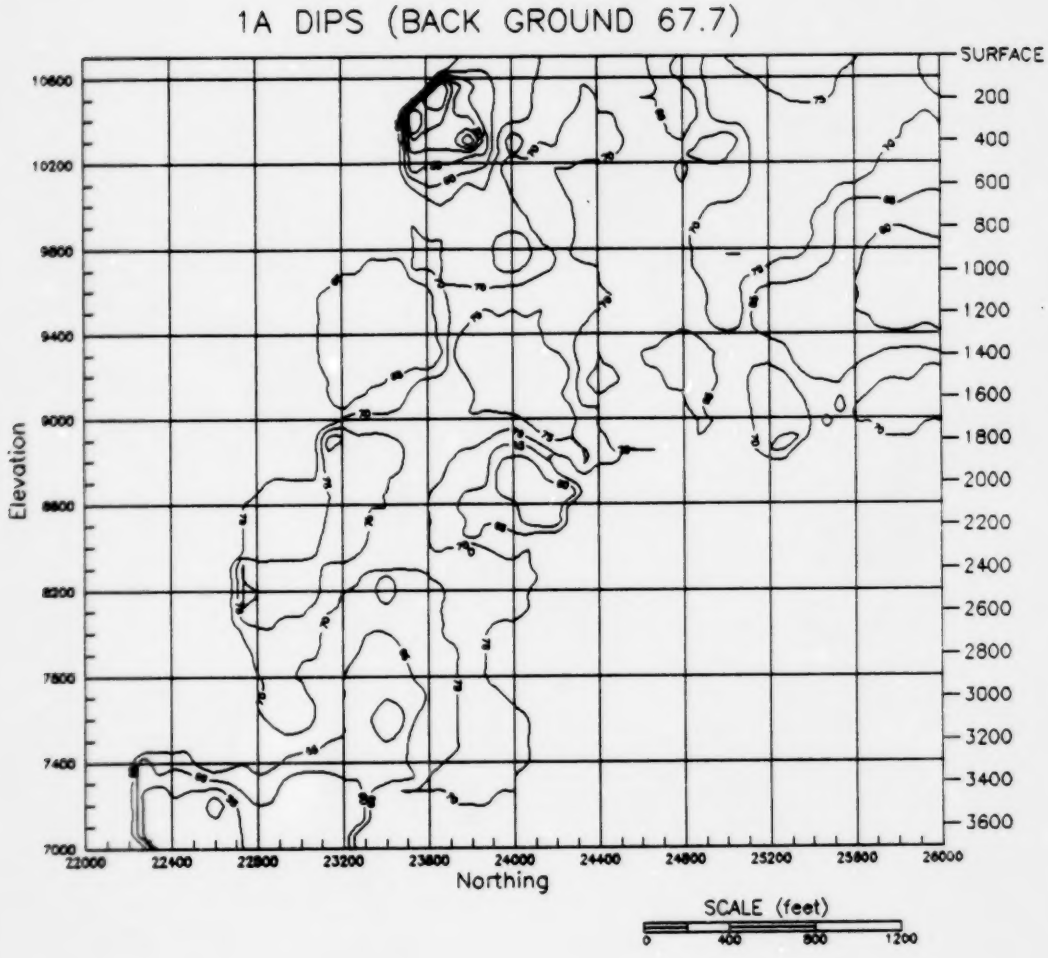

1A DIPS (BACK GROUND 67.7)
SURFACE
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
3000
3200
3400
3600
10600
10200
9800
9400
9000
8600
8200
7800
7400
7000
Elevation
22000
22400
22800
23200
23600
24000
24400
24800
25200
25600
26000
Northing
SCALE (feet)
0
400
800
1200

FIGURE 12C

FIGURE 12D

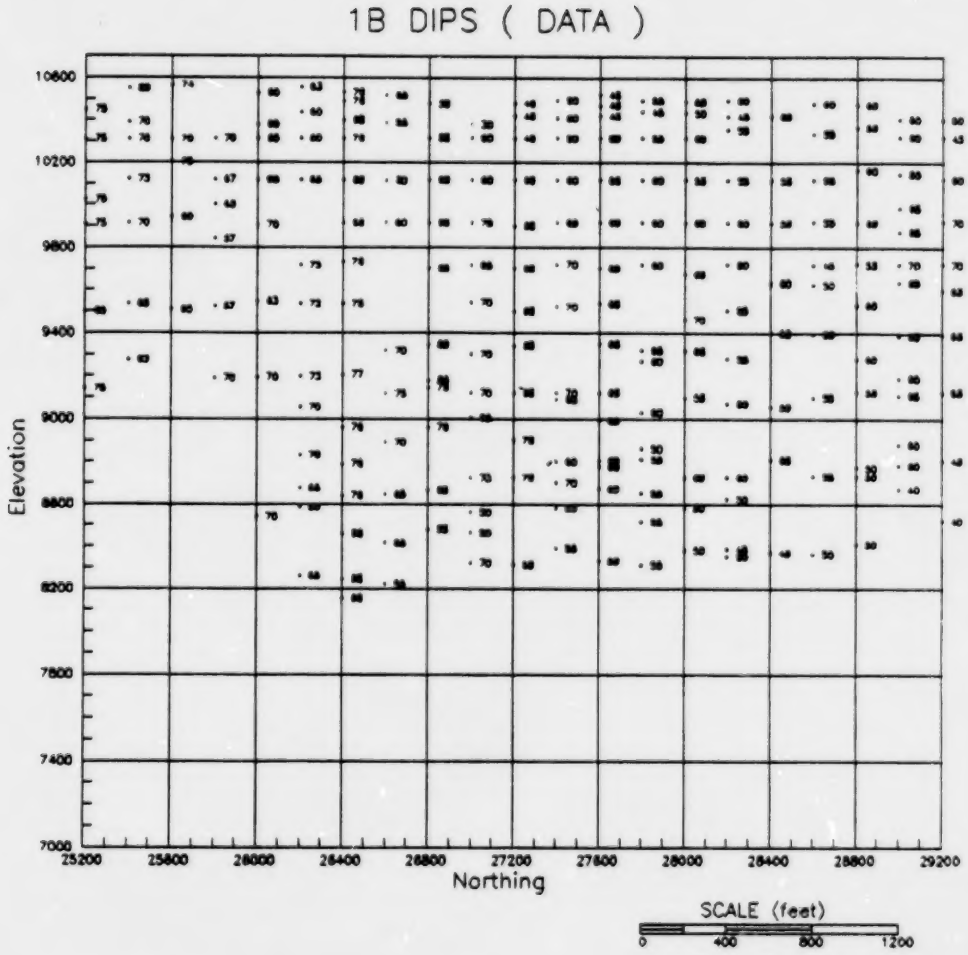

1B DIPS (DATA)
Elevation
10600
10200
9800
9400
9000
8600
8200
7800
7400
7000
25200
25600
26000
26400
26800
27200
27600
28000
28400
28800
29200
Northing
SCALE (feet)
0
400
800
1200

FIGURE 13A

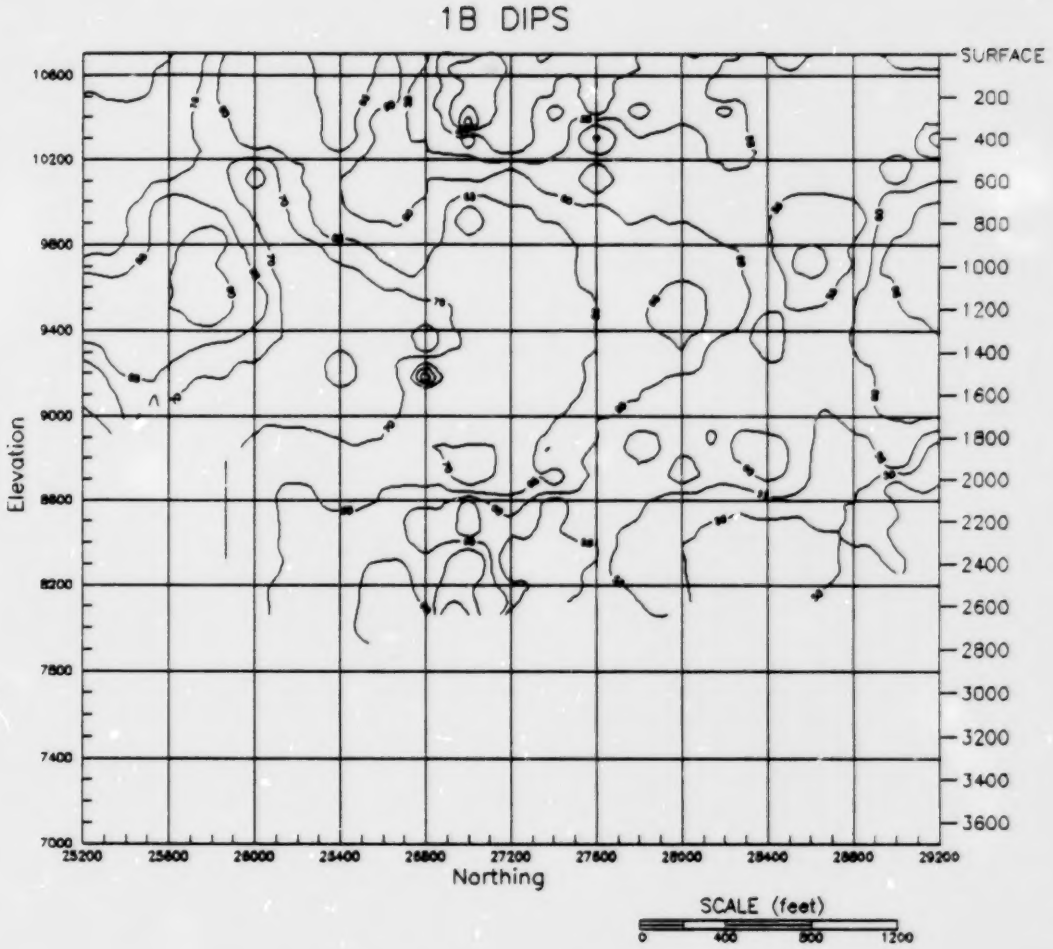

1B DIPS
SURFACE
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
3000
3200
3400
3600
10600
10200
9800
9400
9000
8600
8200
7800
7400
7000
Elevation
25200
25600
26000
26400
26800
27200
27600
28000
28400
28800
29200
Northing
SCALE (feet)
0
400
800
1200

FIGURE 13B

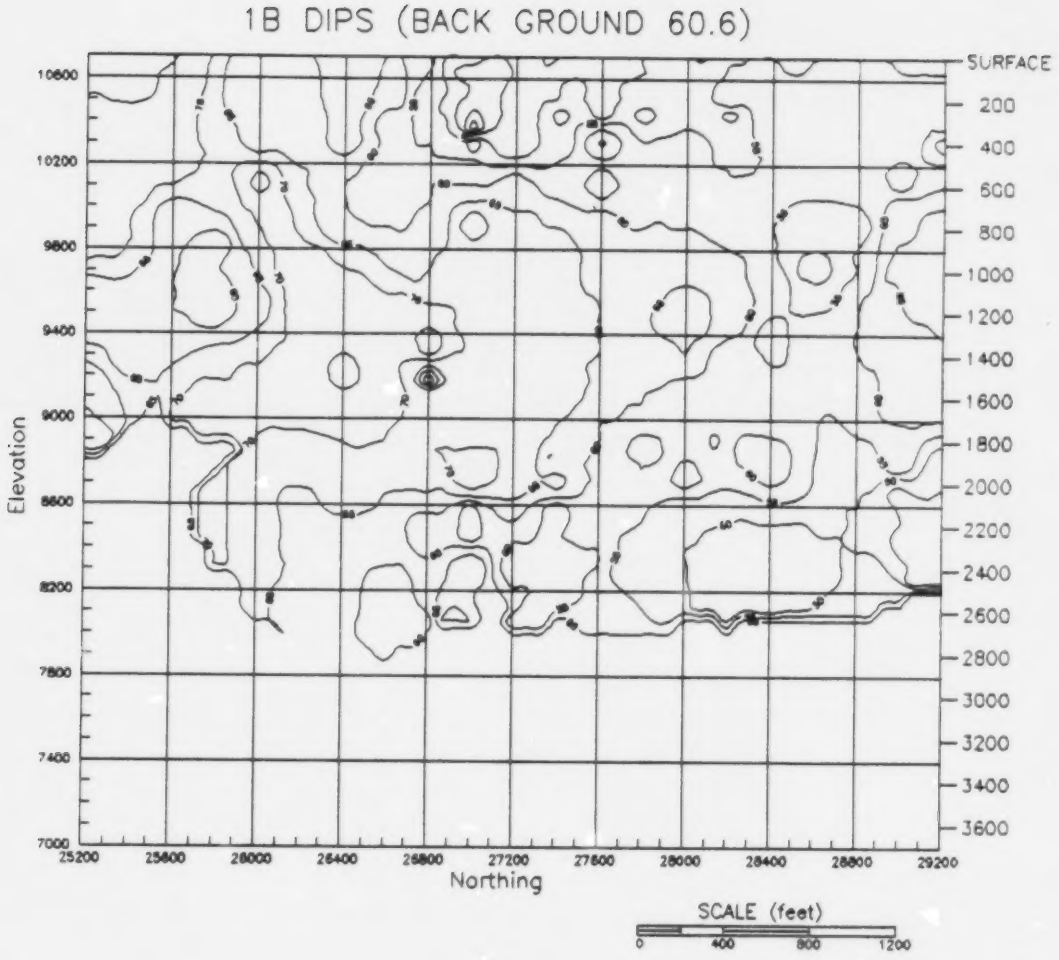

1B DIPS (BACK GROUND 60.6)
SURFACE
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
3000
3200
3400
3600
10600
10200
9800
9400
9000
8600
8200
7800
7400
7000
Elevation
25200
25600
26000
26400
26800
27200
27600
28000
28400
28800
29200
Northing
SCALE (feet)
0
400
800
1200

FIGURE 13C

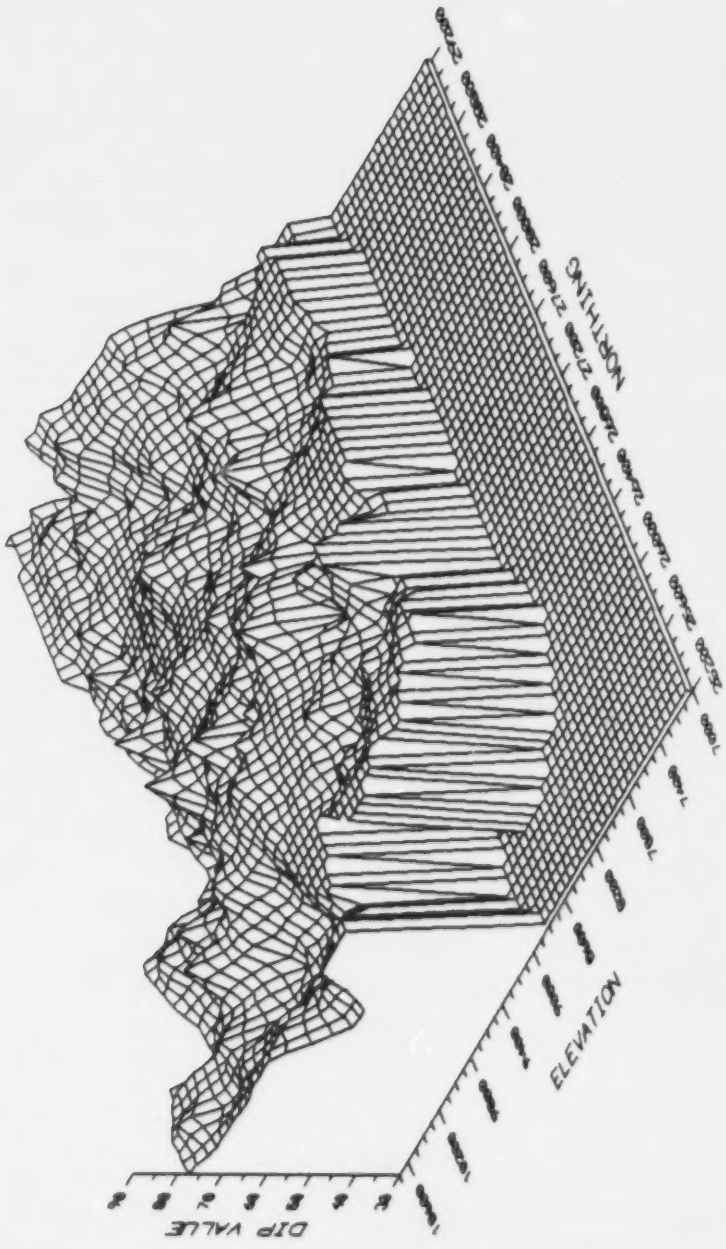


FIGURE 13D

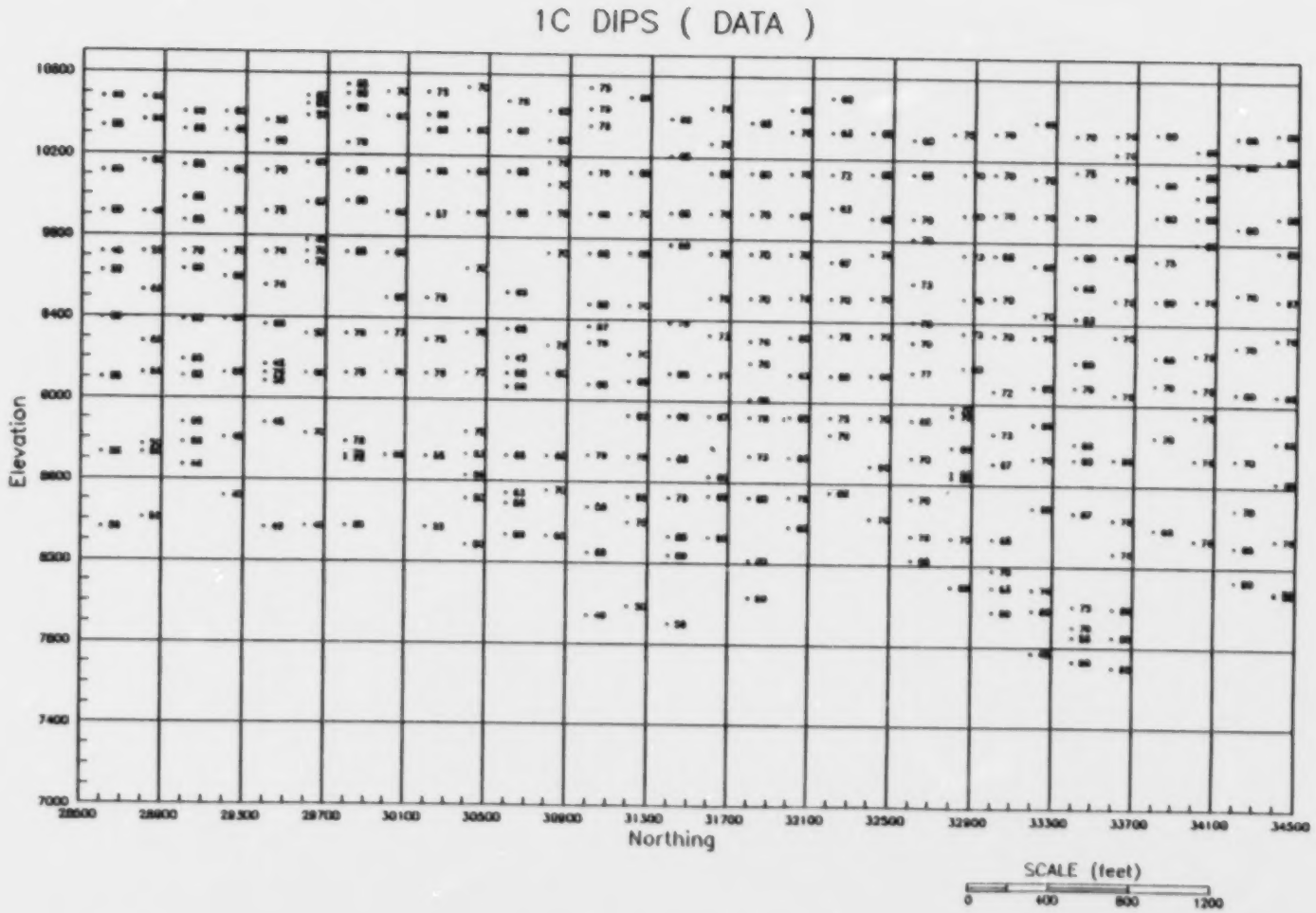

1C DIPS (DATA)
Elevation
10800
10200
9600
9000
8400
7800
7200
7000
28500
28900
29300
29700
30100
30500
30900
31300
31700
32100
32500
32900
33300
33700
34100
34500
Northing
SCALE (feet)
0
400
800
1200

FIGURE 14A

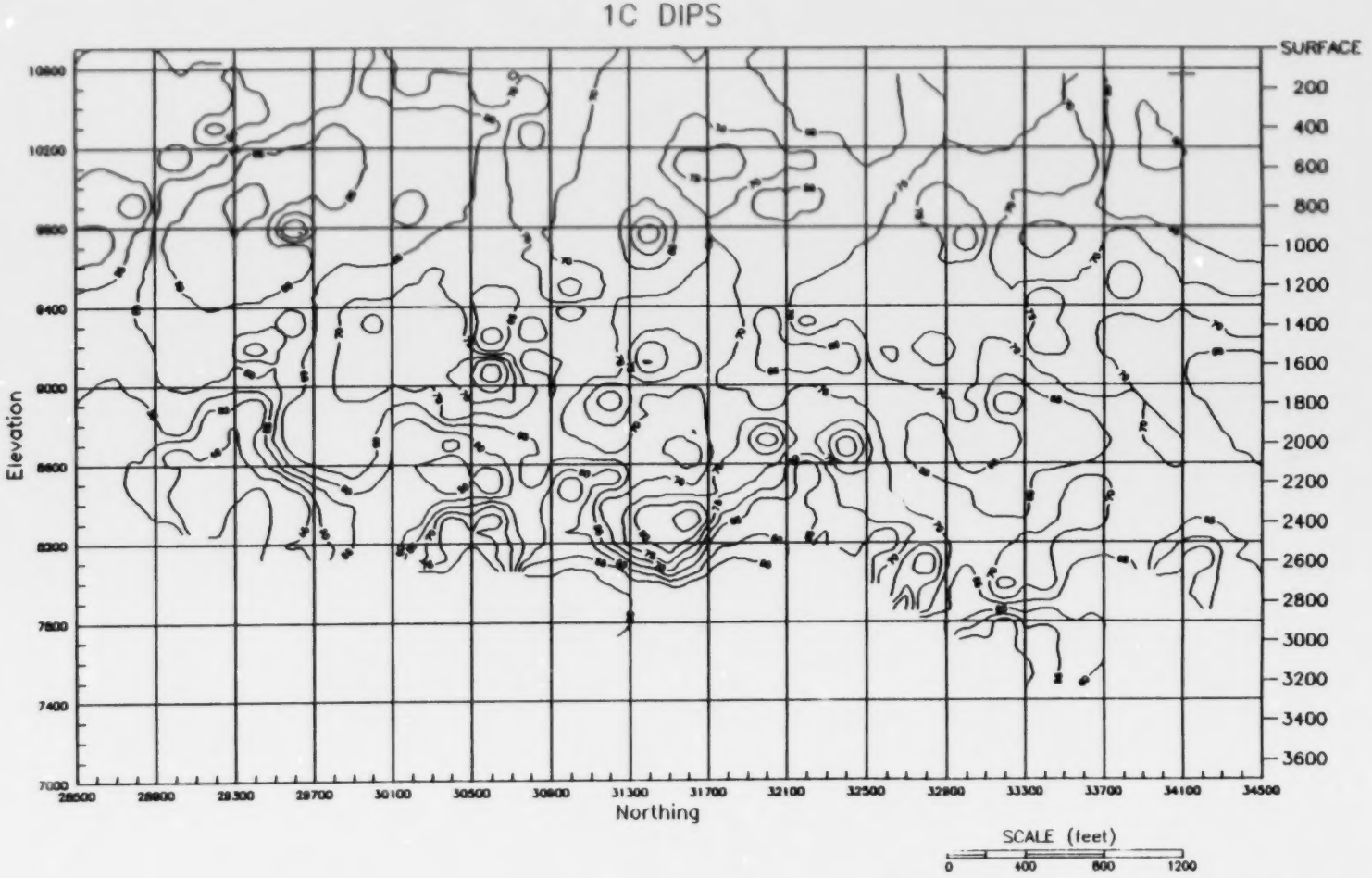

1C DIPS
SURFACE
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
3000
3200
3400
3600
Elevation
10800
10200
9600
9400
9000
8800
8200
7800
7400
7000
28500
28900
29300
29700
30100
30500
30900
31300
31700
32100
32500
32900
33300
33700
34100
34500
Northing
SCALE (feet)
0
400
800
1200

FIGURE 14B

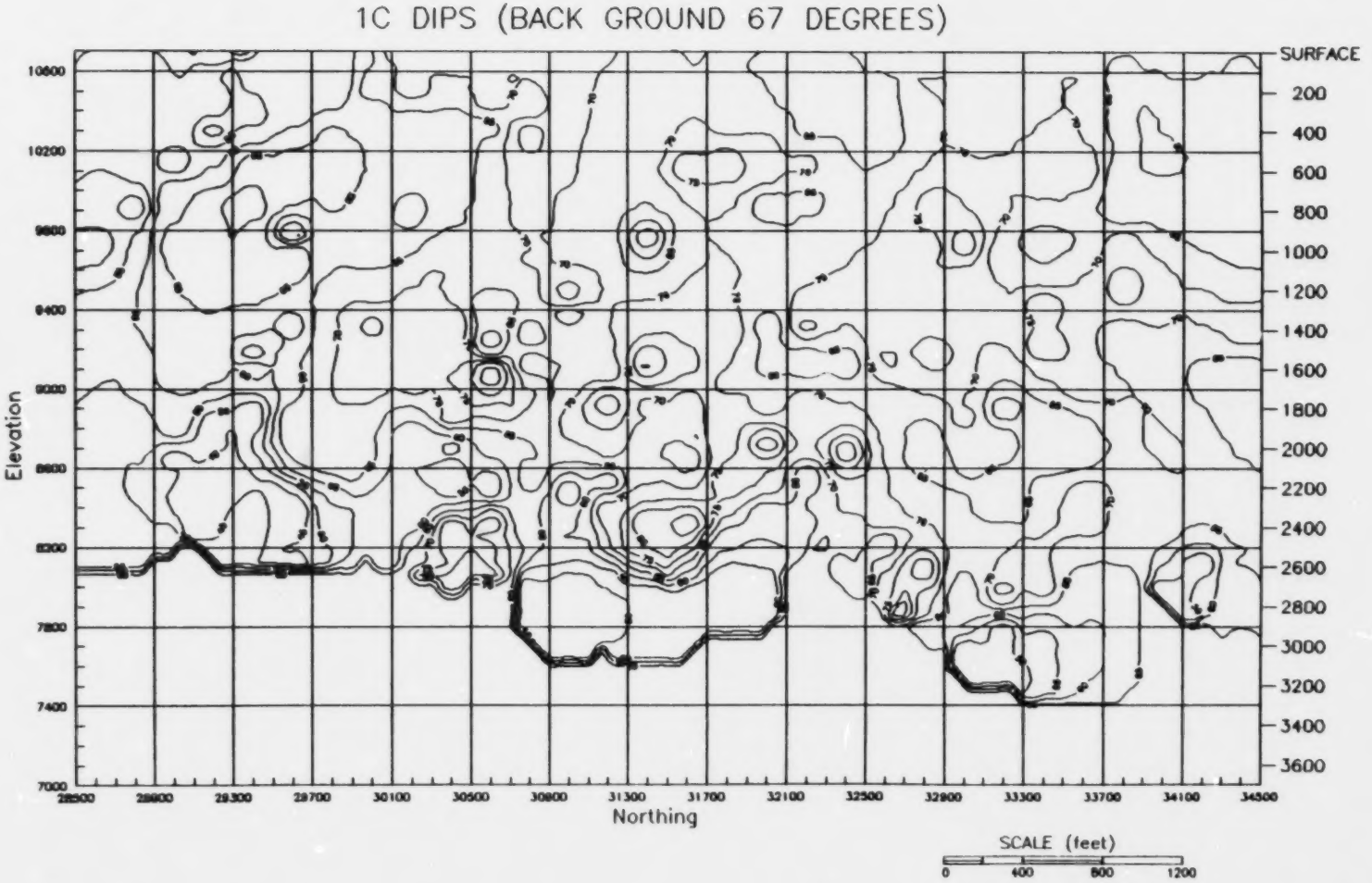

1C DIPS (BACK GROUND 67 DEGREES)
Elevation
Northing
SURFACE
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
3000
3200
3400
3600
10600
10200
9800
9400
9000
8600
8200
7800
7400
7000
28500
28900
29300
29700
30100
30500
30900
31300
31700
32100
32500
32900
33300
33700
34100
34500
SCALE (feet)
0
400
800
1200

FIGURE 14C

FIGURE 14D

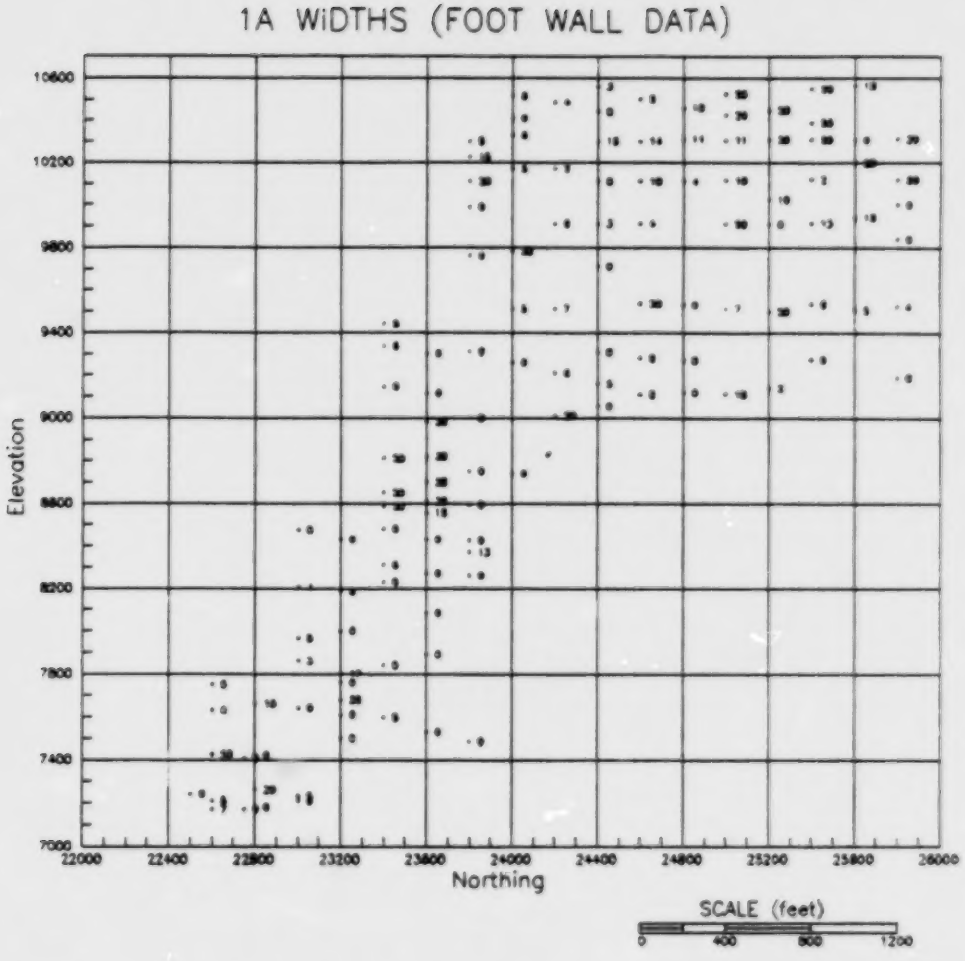

1A WIDTHS (FOOT WALL DATA)
Elevation
10600
10200
9800
9400
9000
8600
8200
7800
7400
7000
22000
22400
22800
23200
23600
24000
24400
24800
25200
25600
26000
Northing
SCALE (feet)
0
400
800
1200

FIGURE 15A

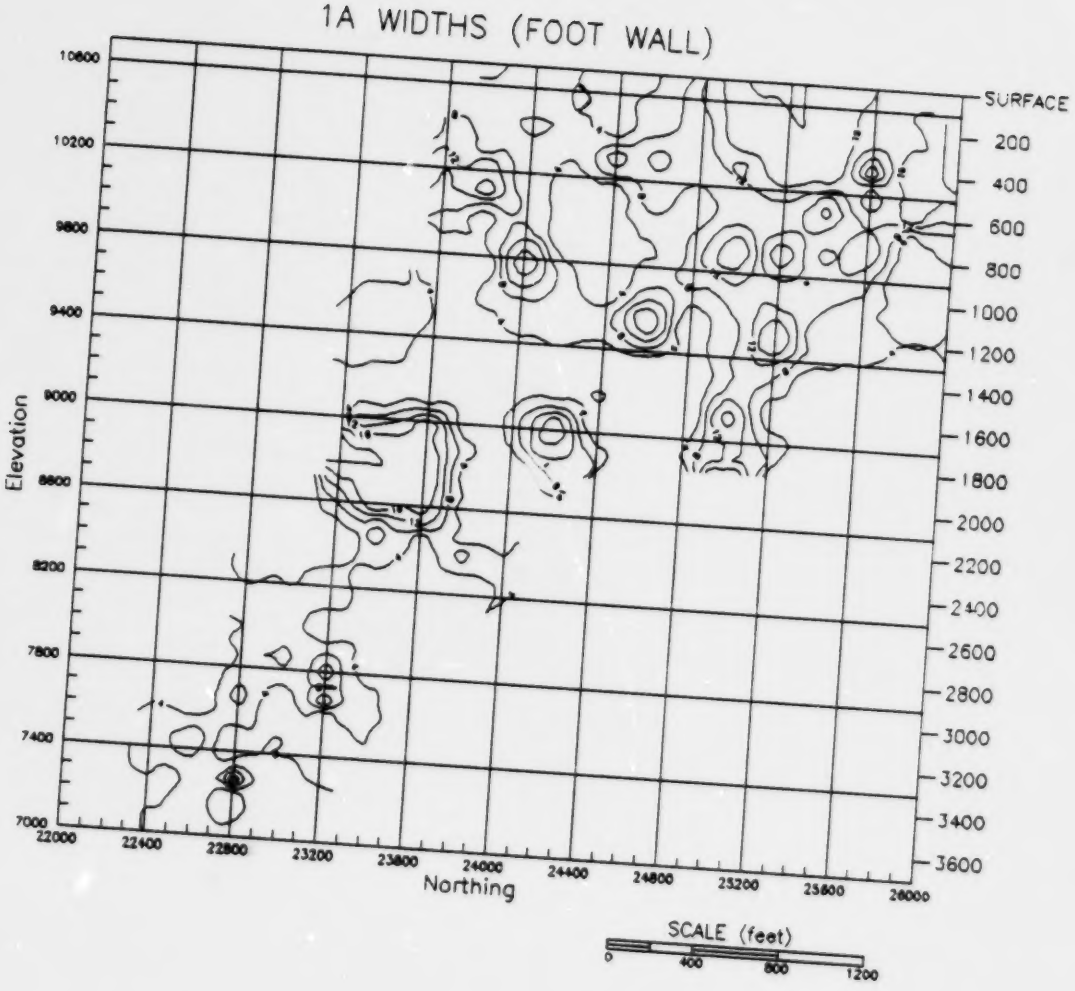

1A WIDTHS (FOOT WALL)
Elevation
10600
10200
9800
9400
9000
8600
8200
7800
7400
7000
SURFACE
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
3000
3200
3400
3600
22000
22400
22800
23200
23800
24000
24400
24800
25200
25600
26000
Northing
SCALE (feet)
0
400
800
1200

FIGURE 15B

FIGURE 15C

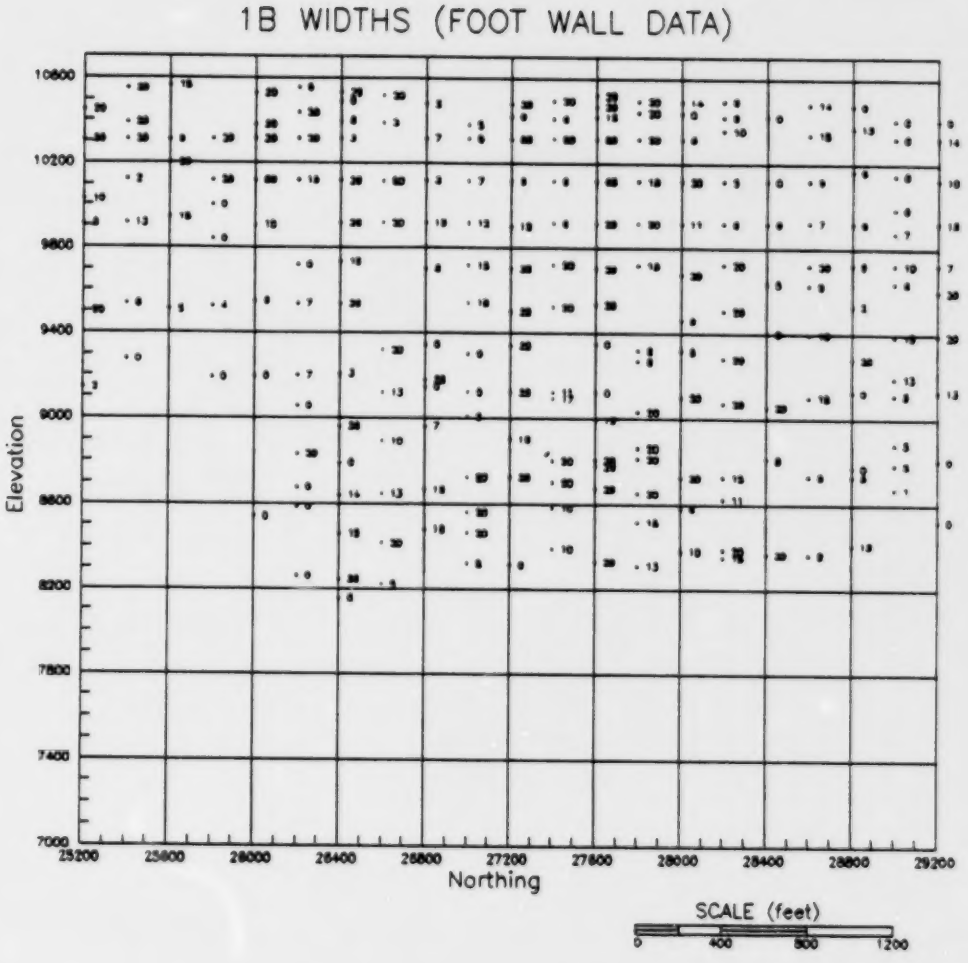

1B WIDTHS (FOOT WALL DATA)
Elevation
10600
10200
9800
9400
9000
8600
8200
7800
7400
7000
25200
25600
26000
26400
26800
27200
27600
28000
28400
28800
29200
Northing
SCALE (feet)
0
400
800
1200

FIGURE 16A

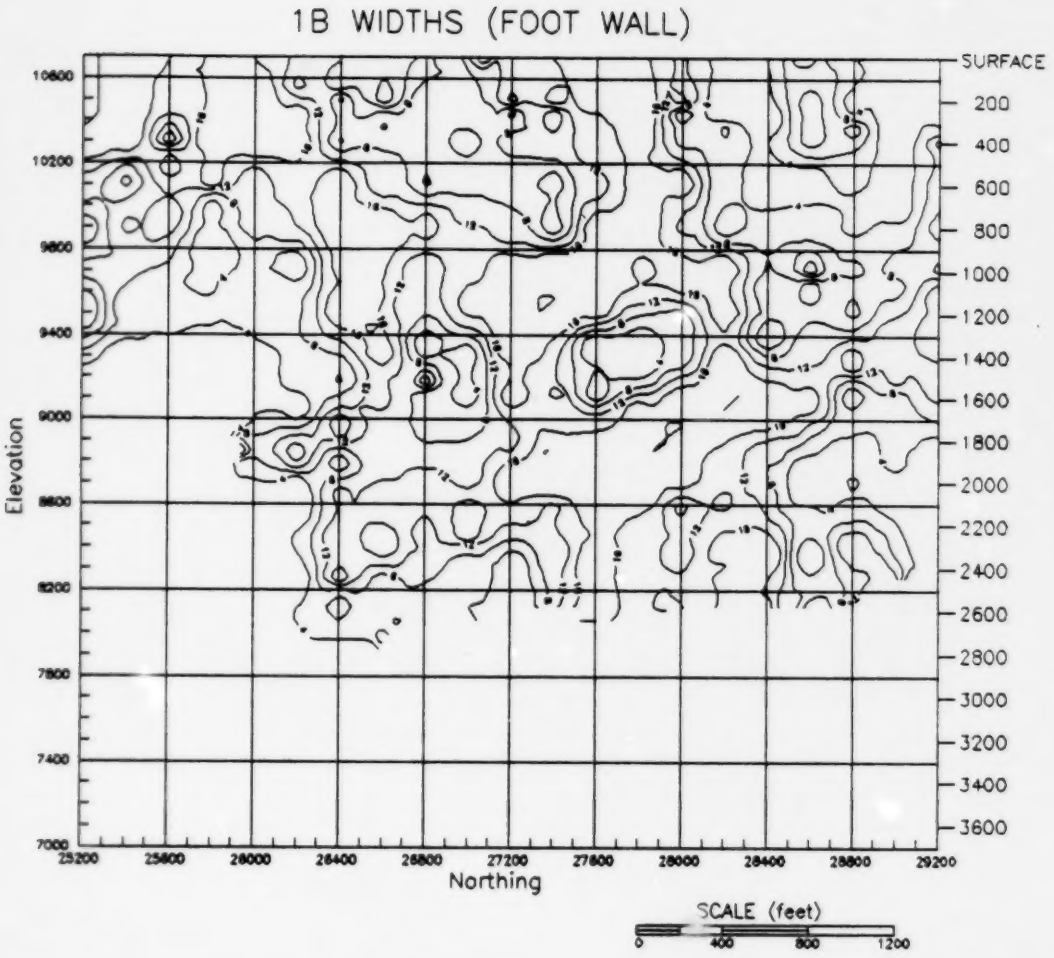

1B WIDTHS (FOOT WALL)
SURFACE
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
3000
3200
3400
3600
Elevation
10600
10200
9800
9400
9000
8600
8200
7800
7400
7000
25200
25600
26000
26400
26800
27200
27600
28000
28400
28800
29200
Northing
SCALE (feet)
0
400
800
1200

FIGURE 16B

18 FOOT WALL WIDTHS

FIGURE 16C

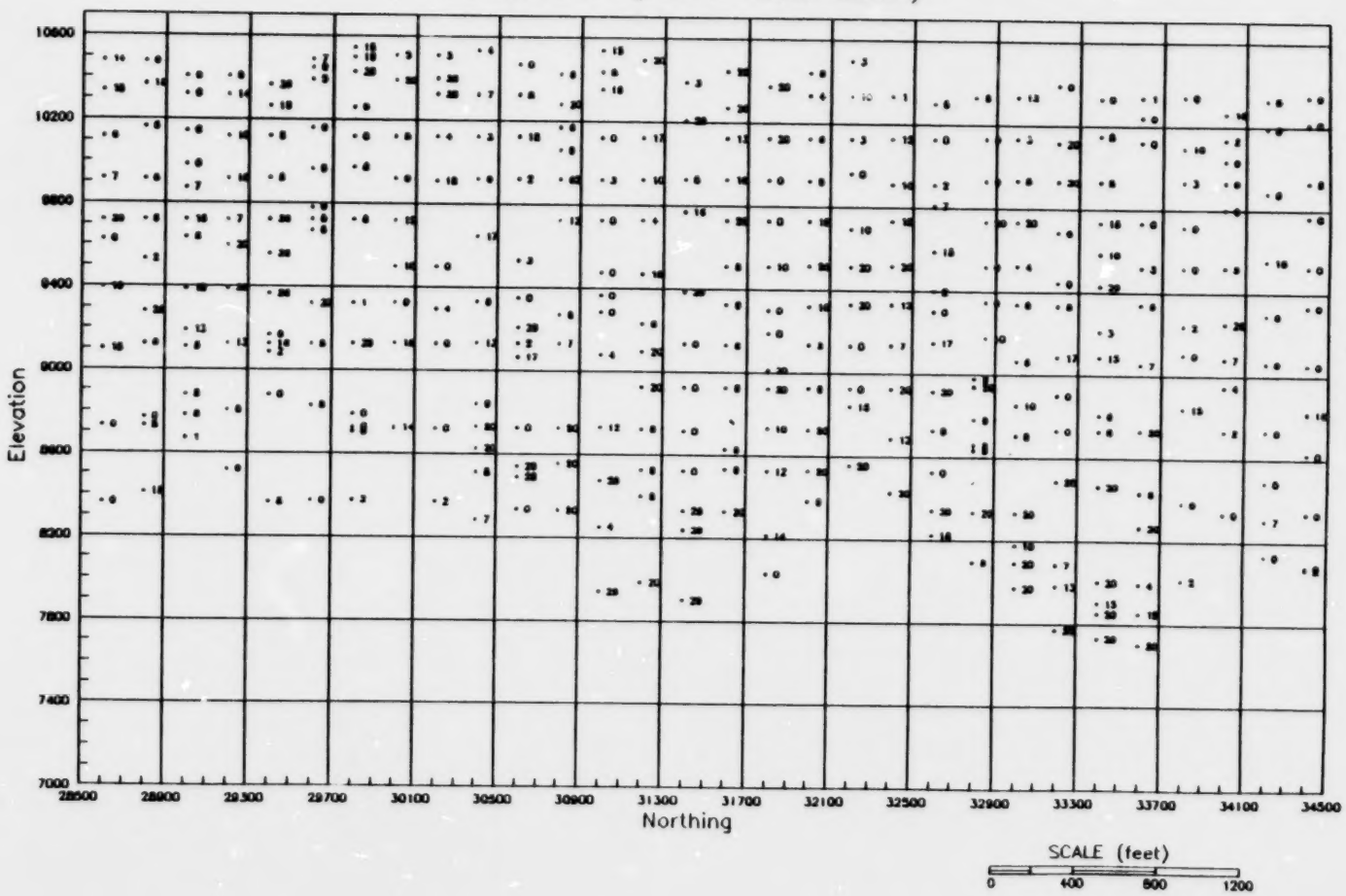

1C WIDTHS (FOOT WALL DATA)
Elevation
10600
10200
9800
9400
9000
8600
8200
7800
7400
7000
28500
28900
29300
29700
30100
30500
30900
31300
31700
32100
32500
32900
33300
33700
34100
34500
Northing
SCALE (feet)
0
400
800
1200

FIGURE 17A

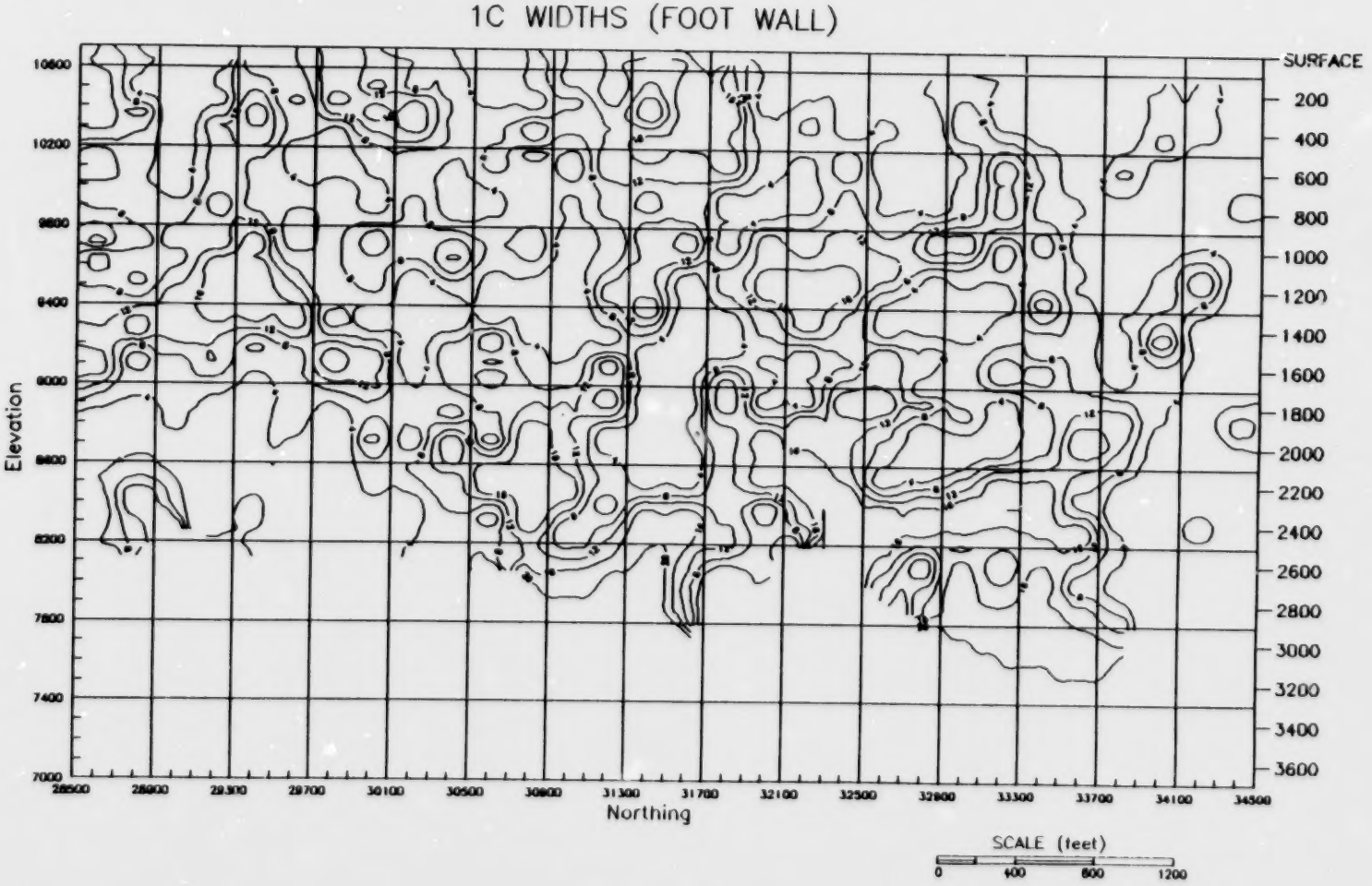

1C WIDTHS (FOOT WALL)
Elevation
Northing
SURFACE
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
3000
3200
3400
3600
10600
10200
9800
9400
9000
8600
8200
7800
7400
7000
28500
28900
29300
29700
30100
30500
30900
31300
31700
32100
32500
32900
33300
33700
34100
34500
SCALE (feet)
0
400
800
1200

FIGURE 17B

1C FOOT WALL WIDTHS

FIGURE 17C

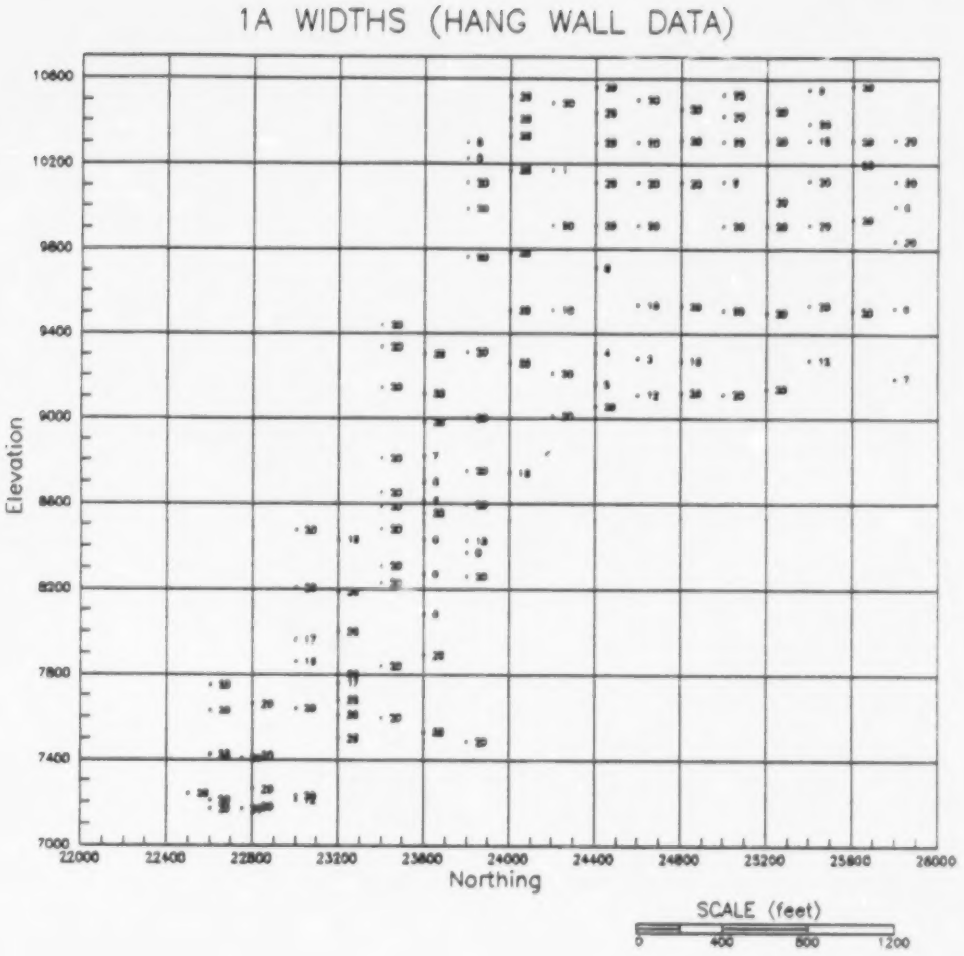

1A WIDTHS (HANG WALL DATA)
Elevation
10600
10200
9800
9400
9000
8600
8200
7800
7400
7000
22000
22400
22800
23200
23600
24000
24400
24800
25200
25600
26000
Northing
SCALE (feet)
0
400
800
1200

FIGURE 18A

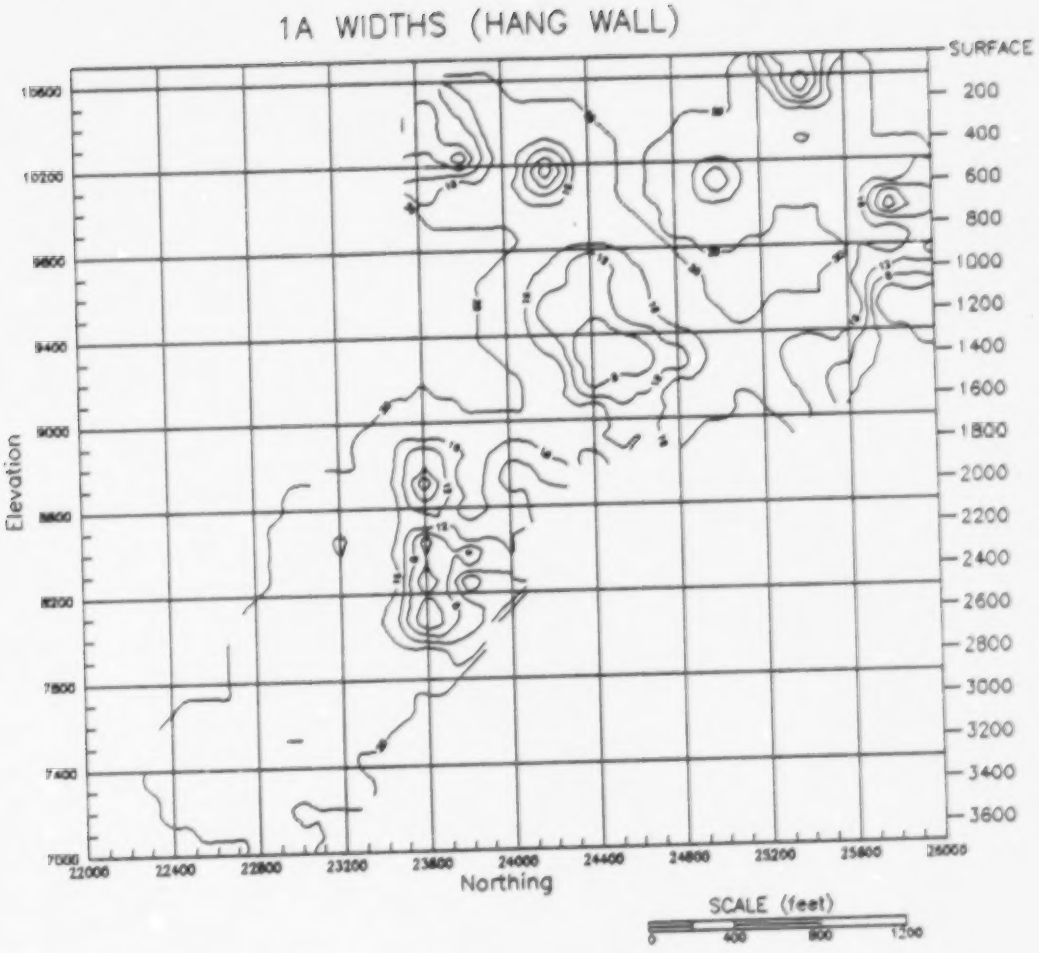

1A WIDTHS (HANG WALL)
SURFACE
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
3000
3200
3400
3600
Elevation
10600
10200
9800
9400
9000
8600
8200
7800
7400
7000
22000
22400
22800
23200
23600
24000
24400
24800
25200
25600
26000
Northing
SCALE (feet)
0
400
800
1200

FIGURE 18B

FIGURE 18C

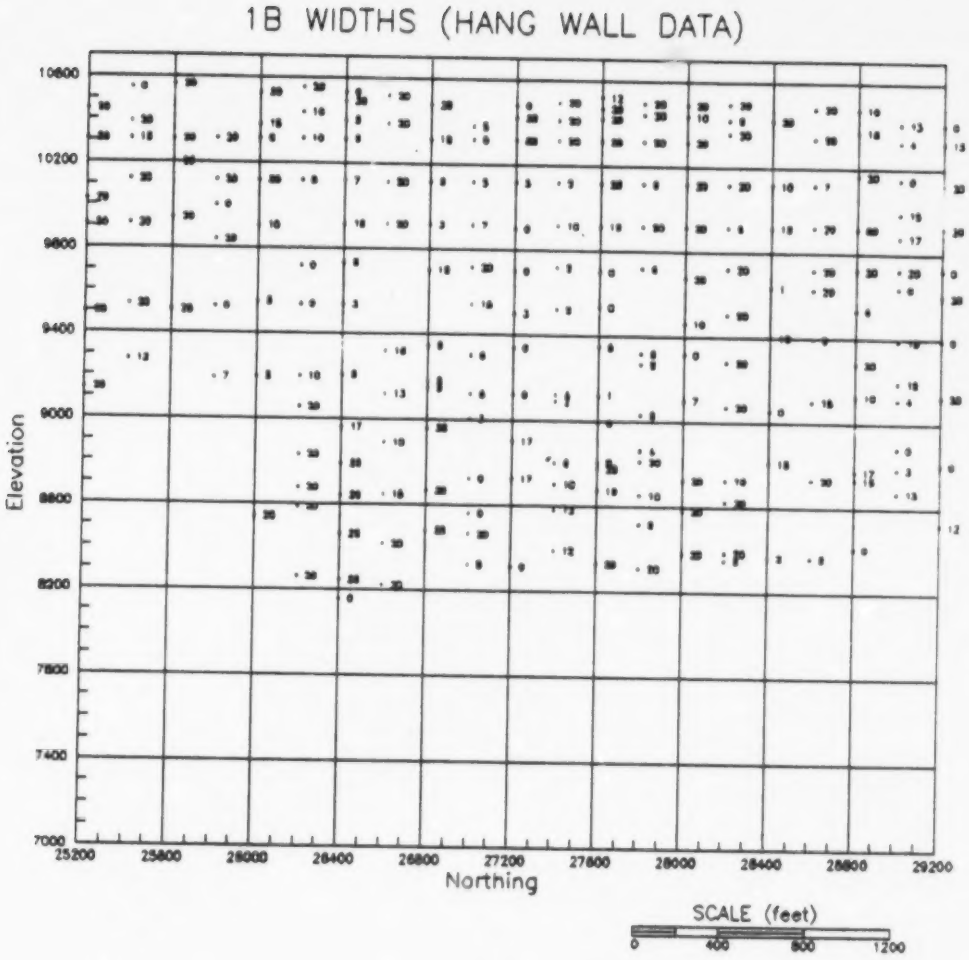

1B WIDTHS (HANG WALL DATA)
Elevation
10600
10200
9800
9400
9000
8600
8200
7800
7400
7000
25200
25600
26000
26400
26800
27200
27600
28000
28400
28800
29200
Northing
SCALE (feet)
0
400
800
1200

FIGURE 19A

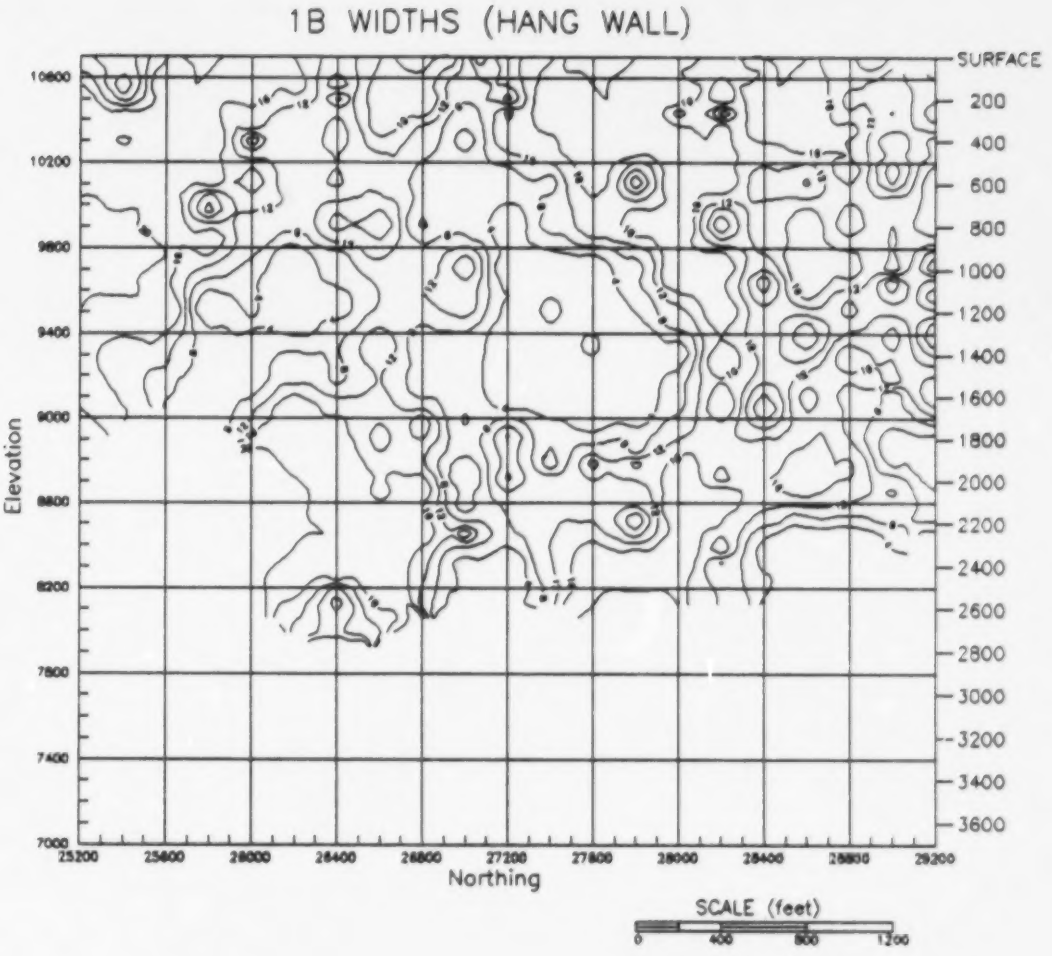

1B WIDTHS (HANG WALL)
Elevation
10600
10200
9800
9400
9000
8800
8200
7800
7400
7000
SURFACE
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
3000
3200
3400
3600
25200
25600
26000
26400
26800
27200
27600
28000
28400
28800
29200
Northing
SCALE (feet)
0
400
800
1200

FIGURE 19B

1B HANG WALL WIDTHS

FIGURE 19C

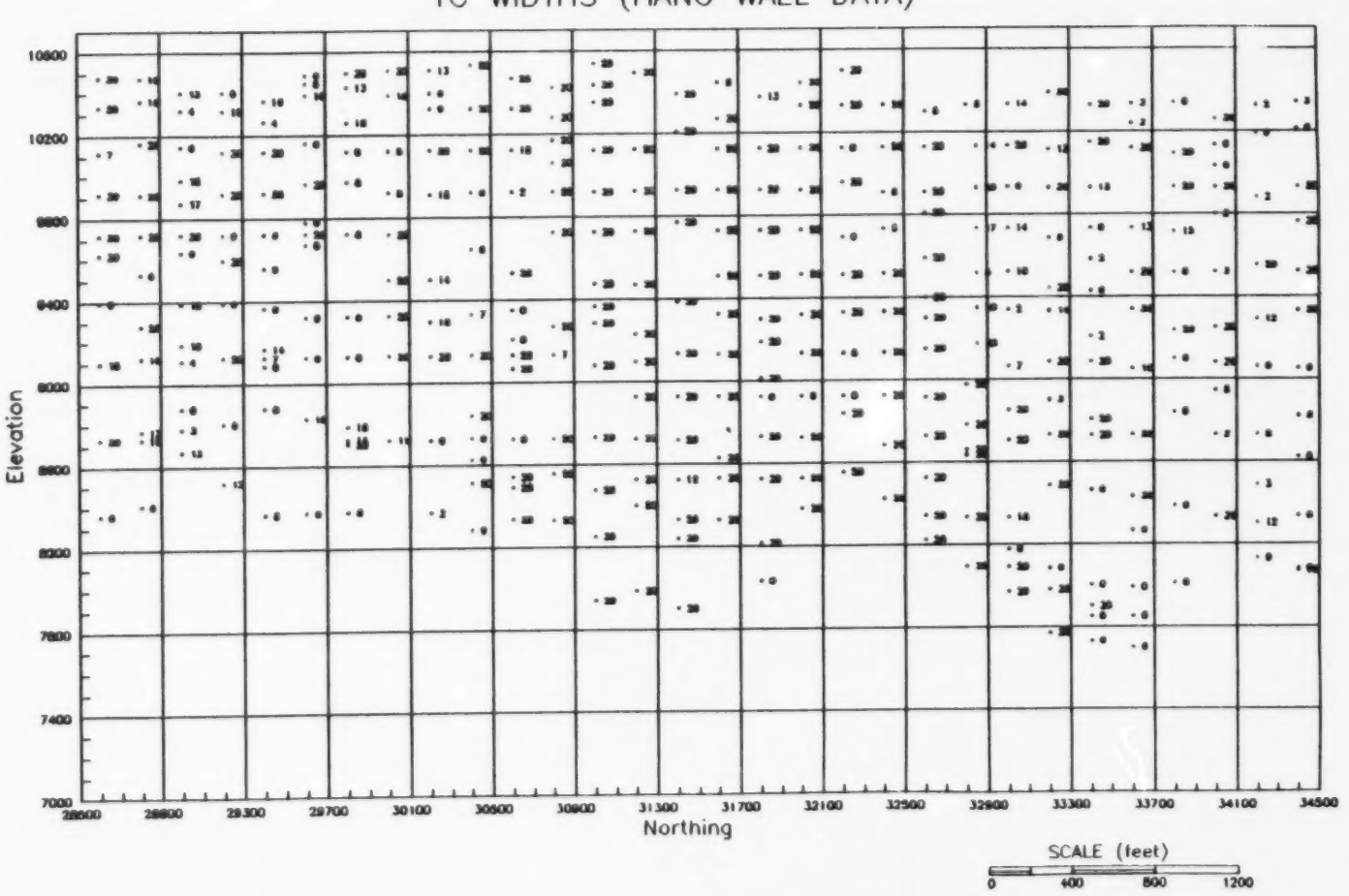

1C WIDTHS (HANG WALL DATA)
Elevation
10600
10200
9800
9400
9000
8600
8200
7800
7400
7000
28600
28800
29300
29700
30100
30500
30800
31300
31700
32100
32500
32900
33300
33700
34100
34500
Northing
SCALE (feet)
0
400
800
1200

FIGURE 20A

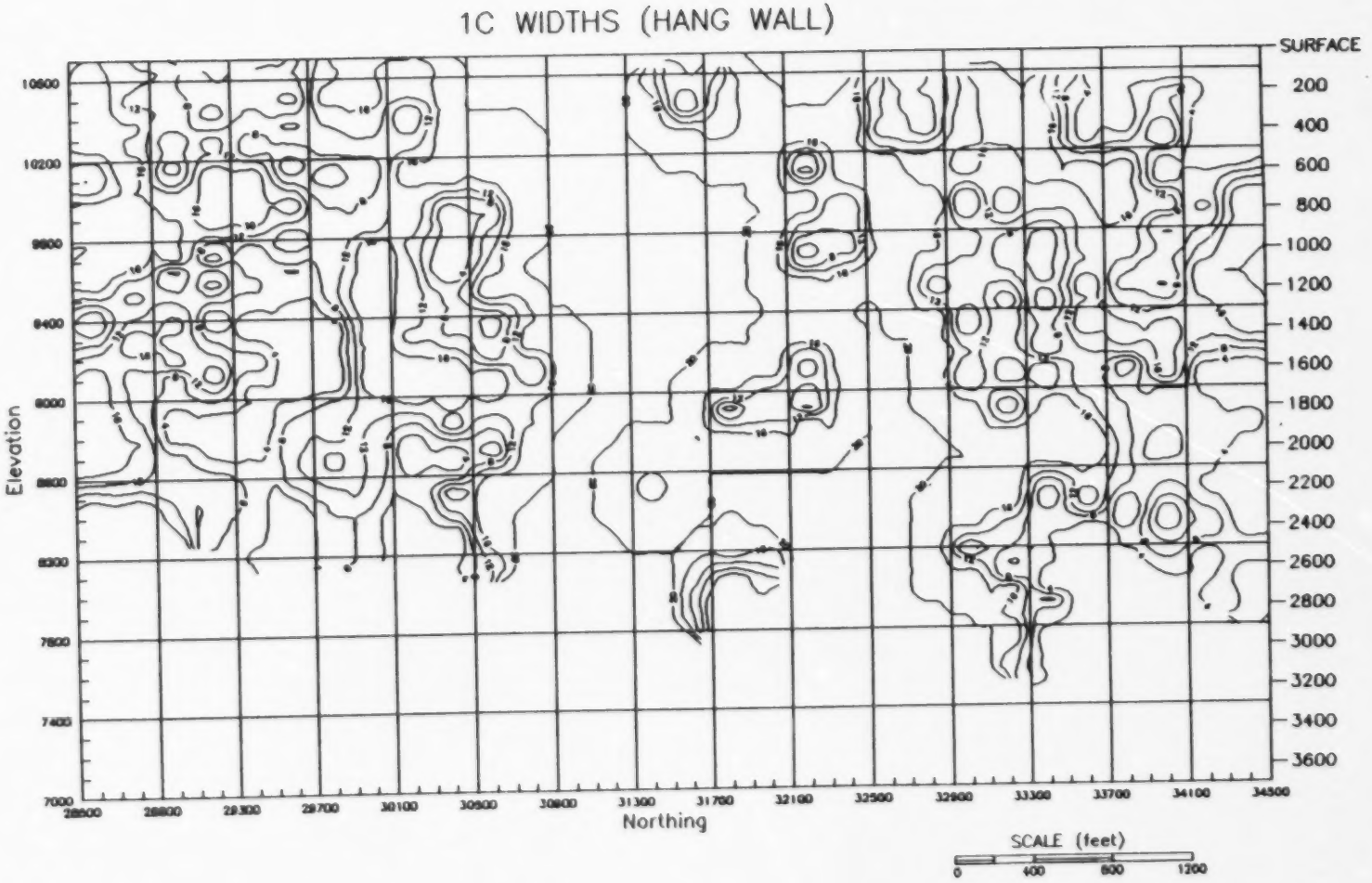

1C WIDTHS (HANG WALL)
SURFACE
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
3000
3200
3400
3600
Elevation
10600
10200
9800
9400
9000
8600
8200
7800
7400
7000
Northing
28500
28800
29300
29700
30100
30500
30800
31300
31700
32100
32500
32900
33300
33700
34100
34500
SCALE (feet)
0
400
800
1200

FIGURE 20B

1C HANG WALL WIDTHS

FIGURE 20C

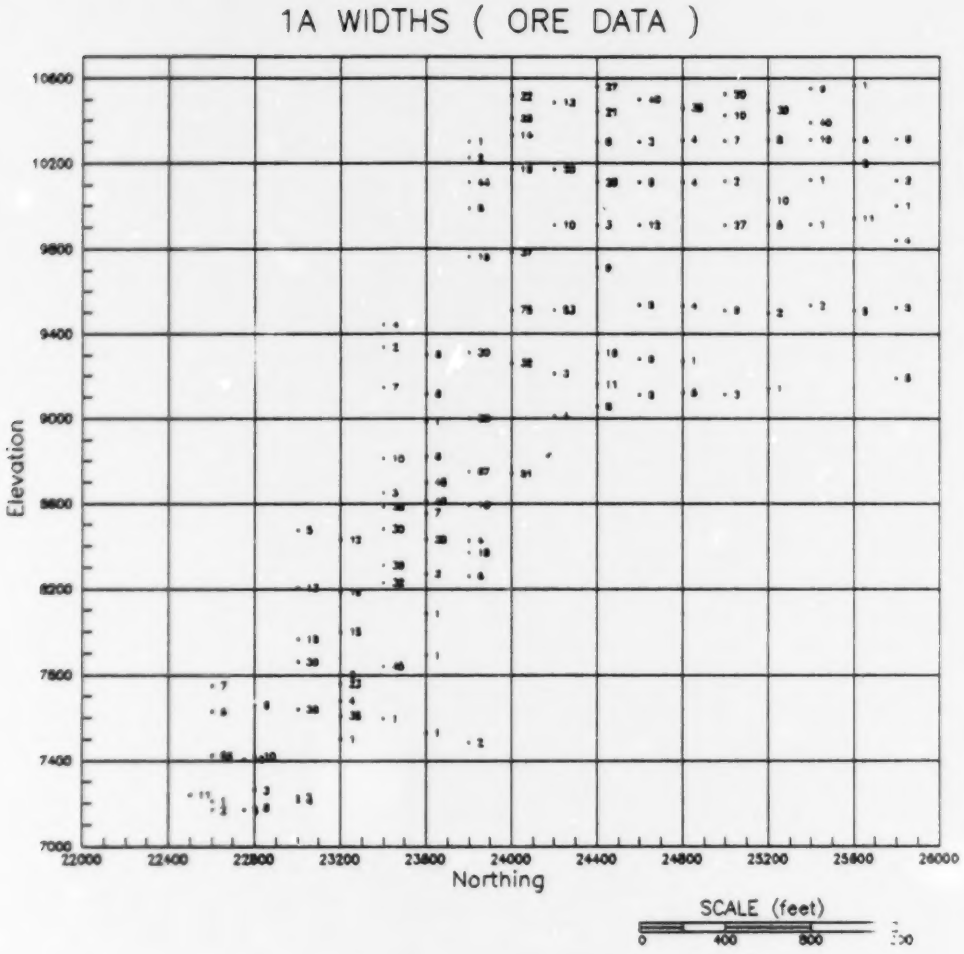

1A WIDTHS (ORE DATA)
Elevation
10600
10200
9800
9400
9000
8600
8200
7800
7400
7000
22000
22400
22800
23200
23800
24000
24400
24800
25200
25600
26000
Northing
SCALE (feet)
0
400
800

FIGURE 21A

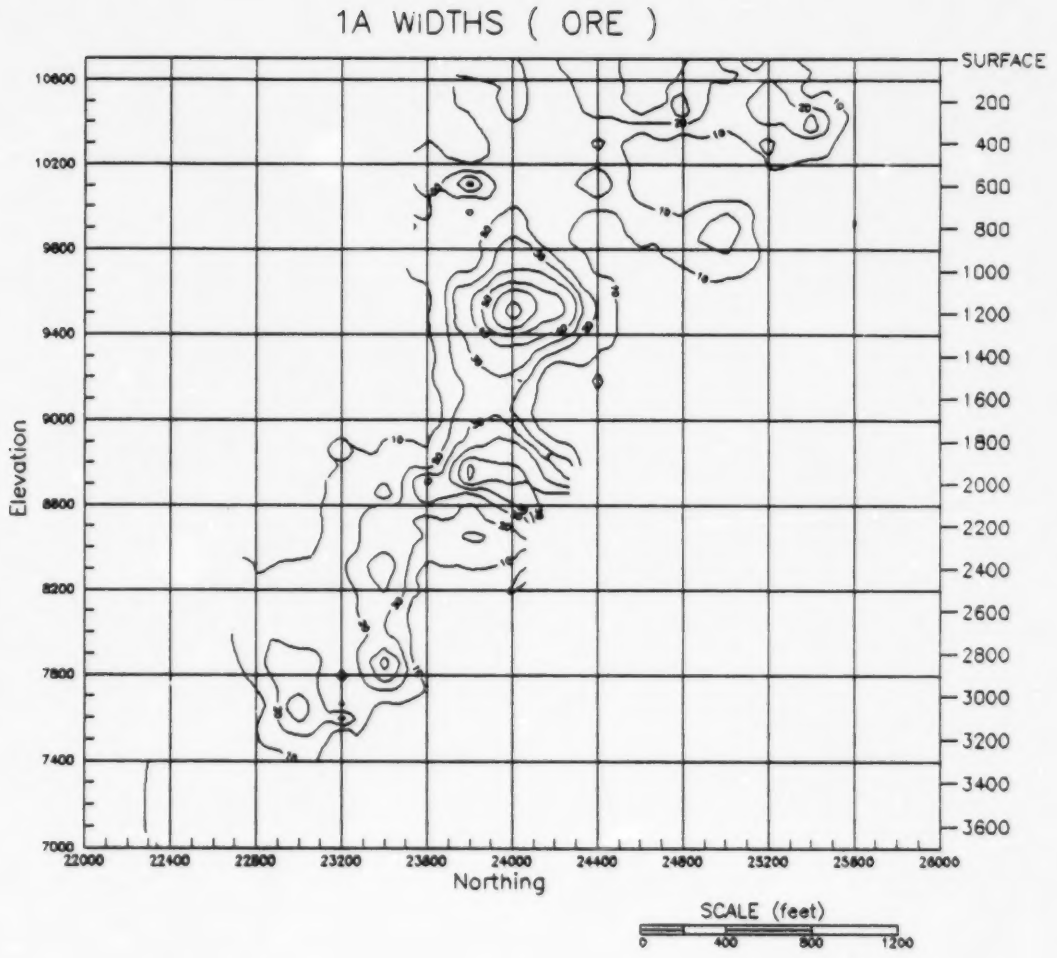

1A WIDTHS (ORE)
SURFACE
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
3000
3200
3400
3600
10600
10200
9800
9400
9000
8600
8200
7800
7400
7000
Elevation
22000
22400
22800
23200
23600
24000
24400
24800
25200
25600
26000
Northing
SCALE (feet)
0
400
800
1200

FIGURE 21B

1A ORE BODY WIDTHS

FIGURE 21C

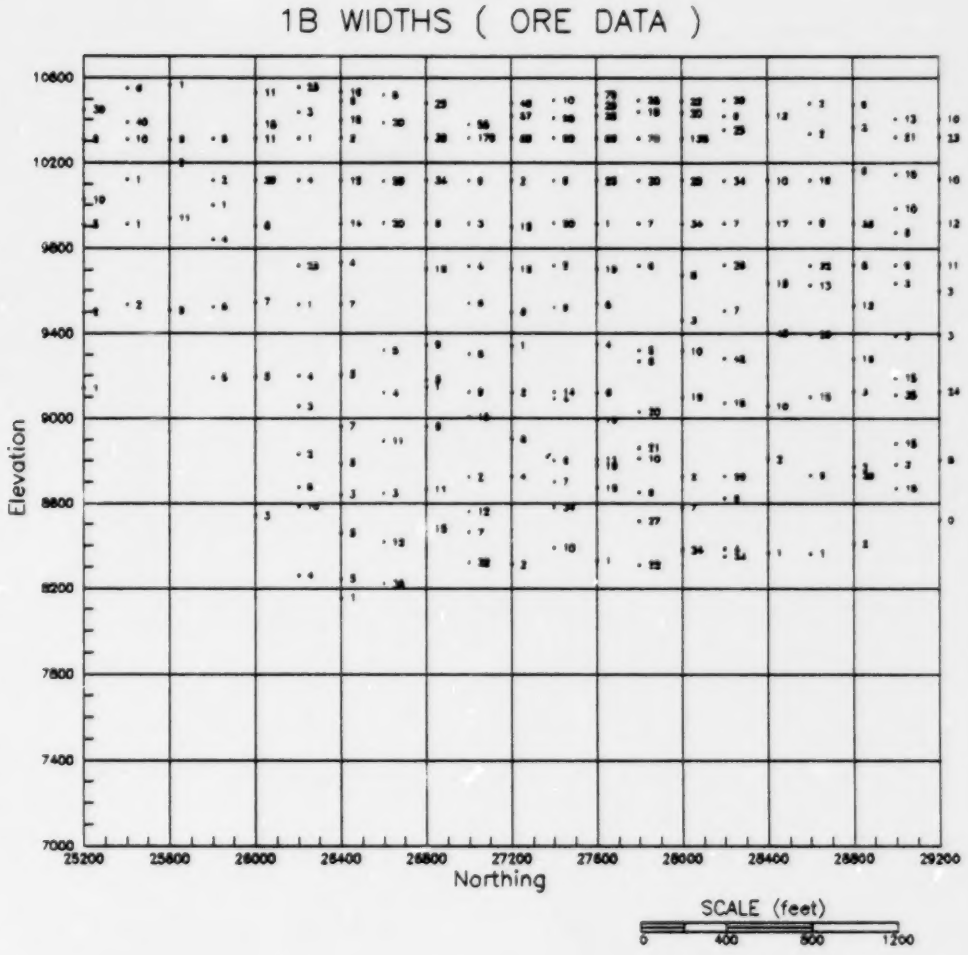

1B WIDTHS (ORE DATA)
Elevation
10600
10200
9800
9400
9000
8600
8200
7800
7400
7000
25200
25600
26000
26400
26800
27200
27600
28000
28400
28800
29200
Northing
SCALE (feet)
0
400
800
1200

FIGURE 22A

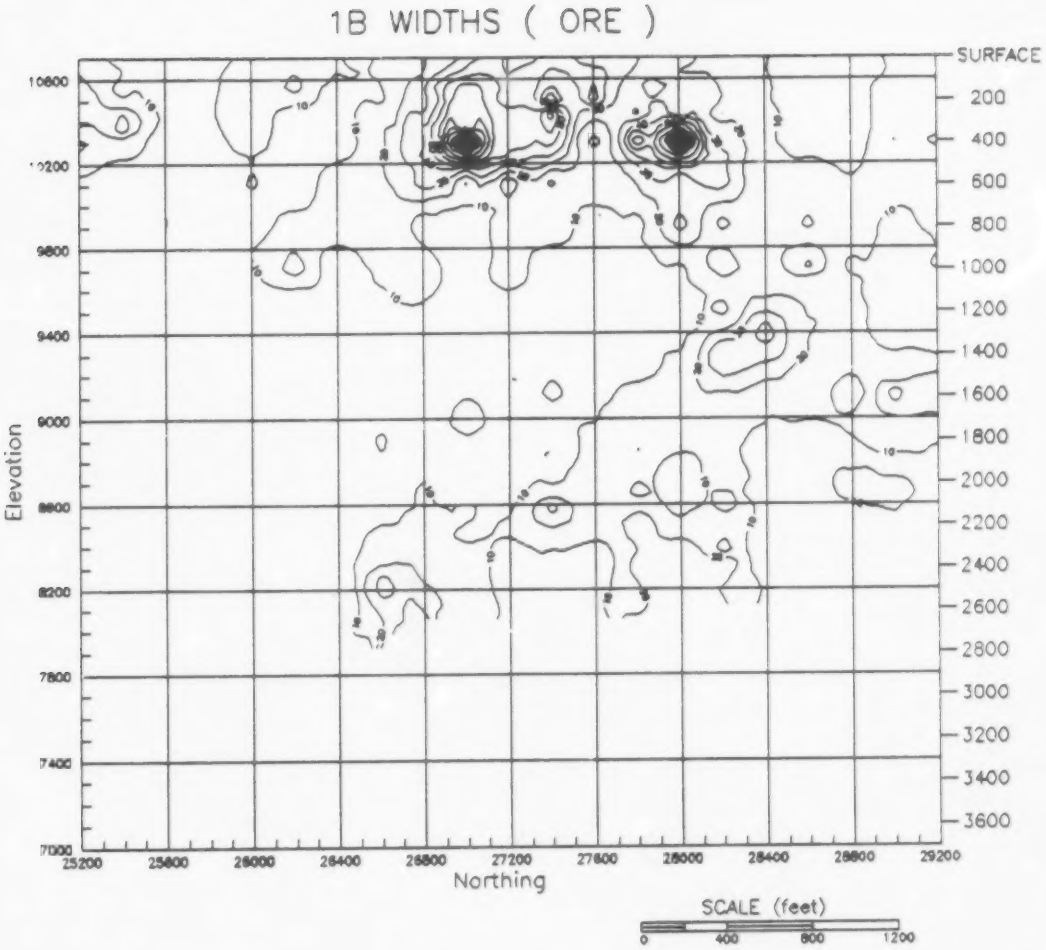

1B WIDTHS (ORE)
SURFACE
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
3000
3200
3400
3600
Elevation
10600
10200
9800
9400
9000
8600
8200
7800
7400
7000
25200
25600
26000
26400
26800
27200
27600
28000
28400
28800
29200
Northing
SCALE (feet)
0
400
800
1200

FIGURE 22B

1B ORE BODY WIDTHS

FIGURE 22C

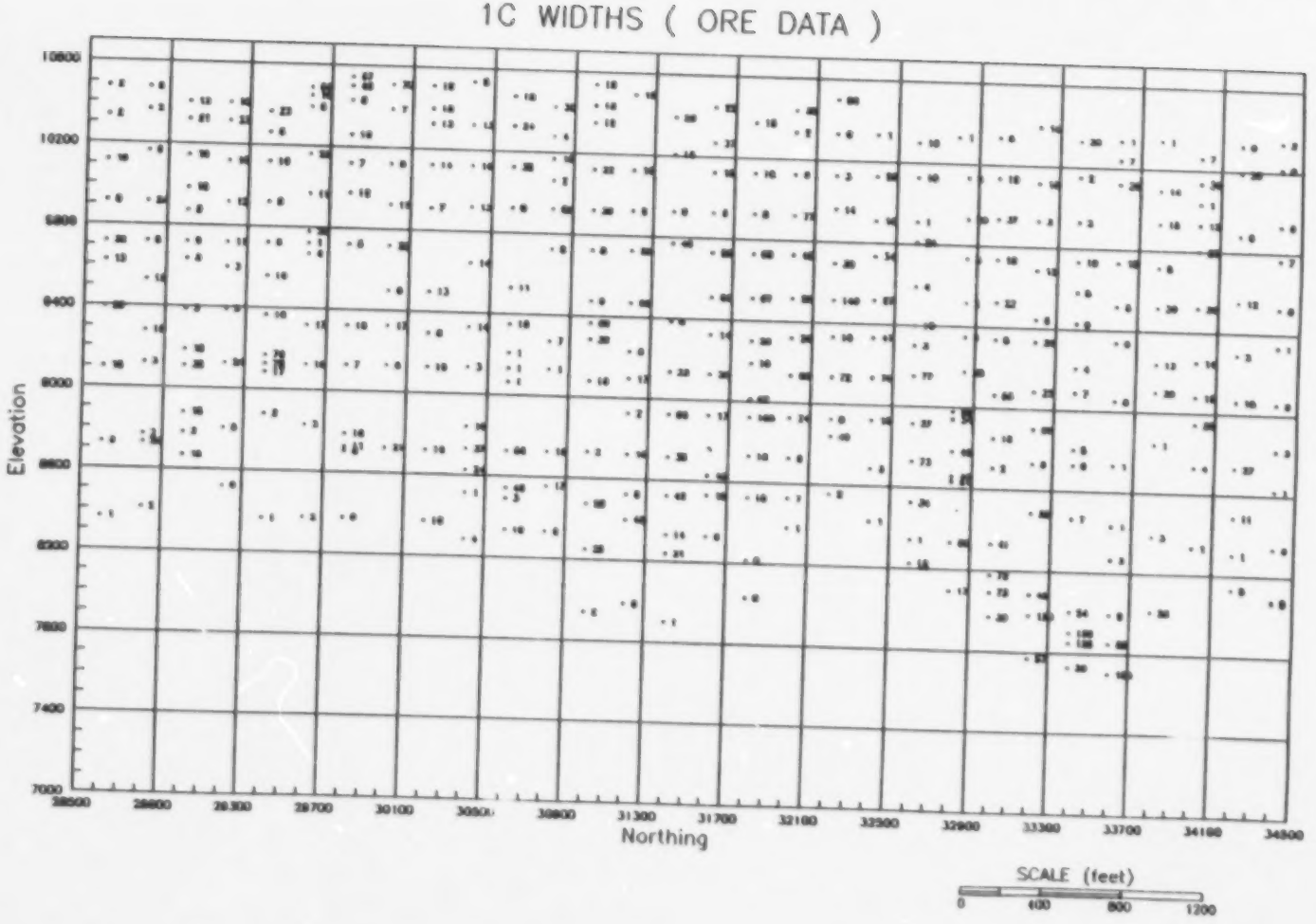

1C WIDTHS (ORE DATA)
Elevation
10600
10200
9800
9400
9000
8600
8200
7800
7400
7000
28500
28900
29300
29700
30100
30500
30900
31300
31700
32100
32500
32900
33300
33700
34100
34500
Northing
SCALE (feet)
0
400
800
1200

FIGURE 23A

1C WIDTHS (ORE)
SURFACE
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
3000
3200
3400
3600
Elevation
Northing
SCALE (feet)
0
400
800
1200

FIGURE 23B

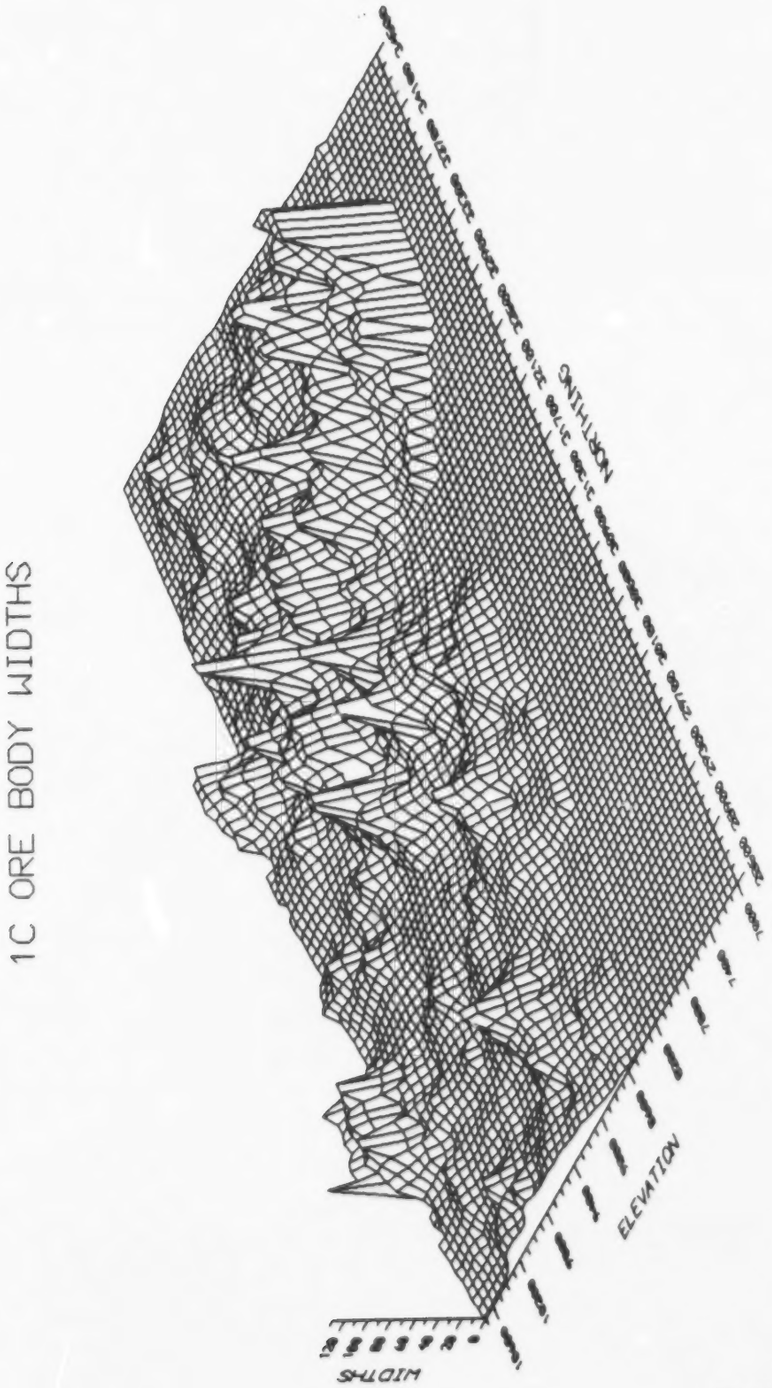


FIGURE 23C

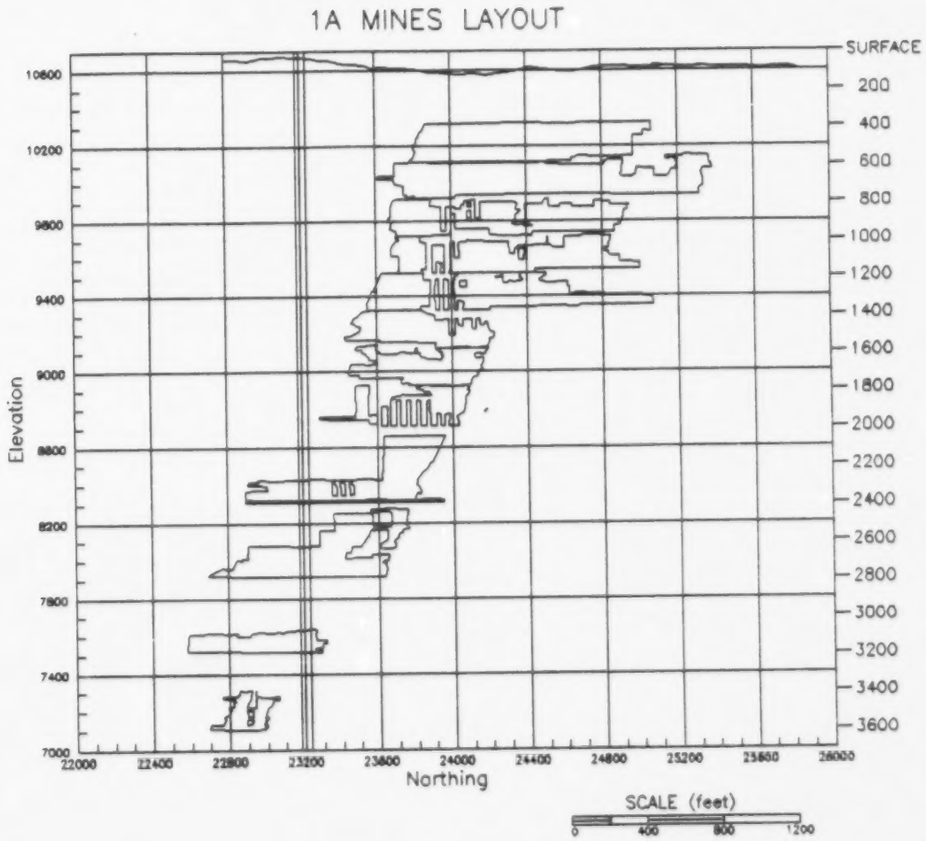


FIGURE 24A

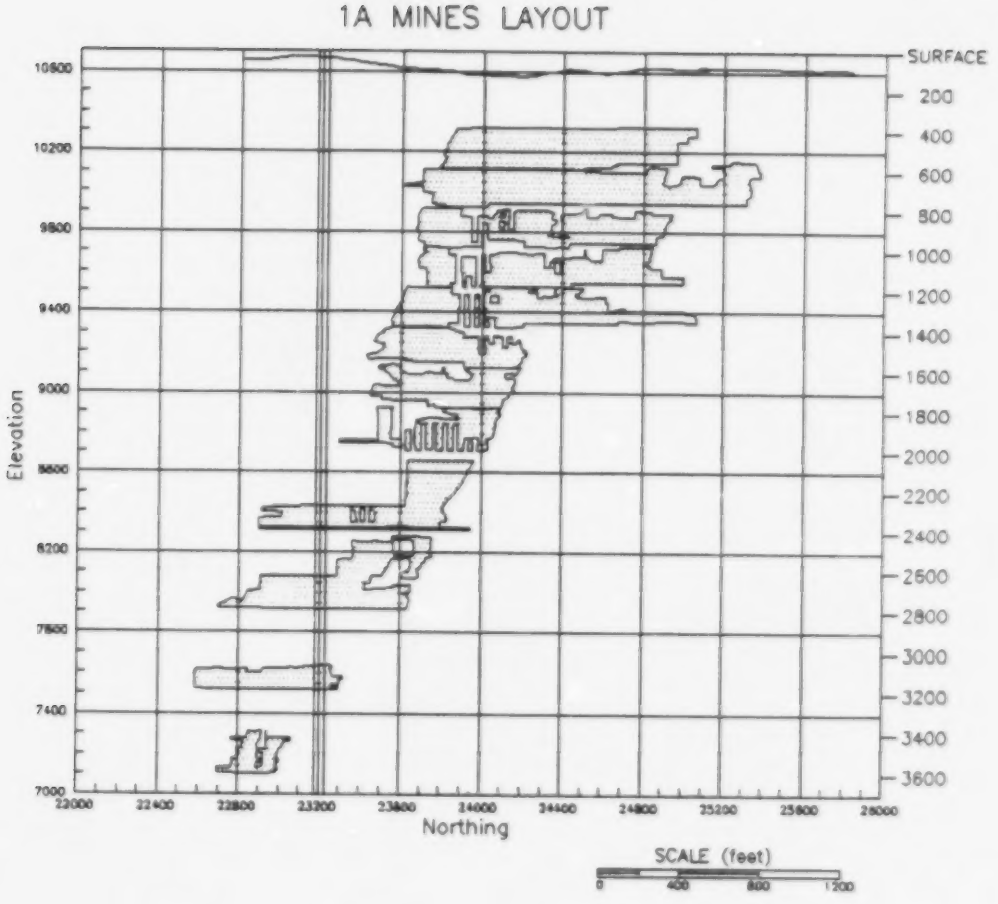

1A MINES LAYOUT
SURFACE
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
3000
3200
3400
3600
10800
10200
9800
9400
9000
8600
8200
7800
7400
7000
Elevation
22000
22400
22800
23200
23600
24000
24400
24800
25200
25600
26000
Northing
SCALE (feet)
0
400
800
1200

FIGURE 24B

Mining Methods

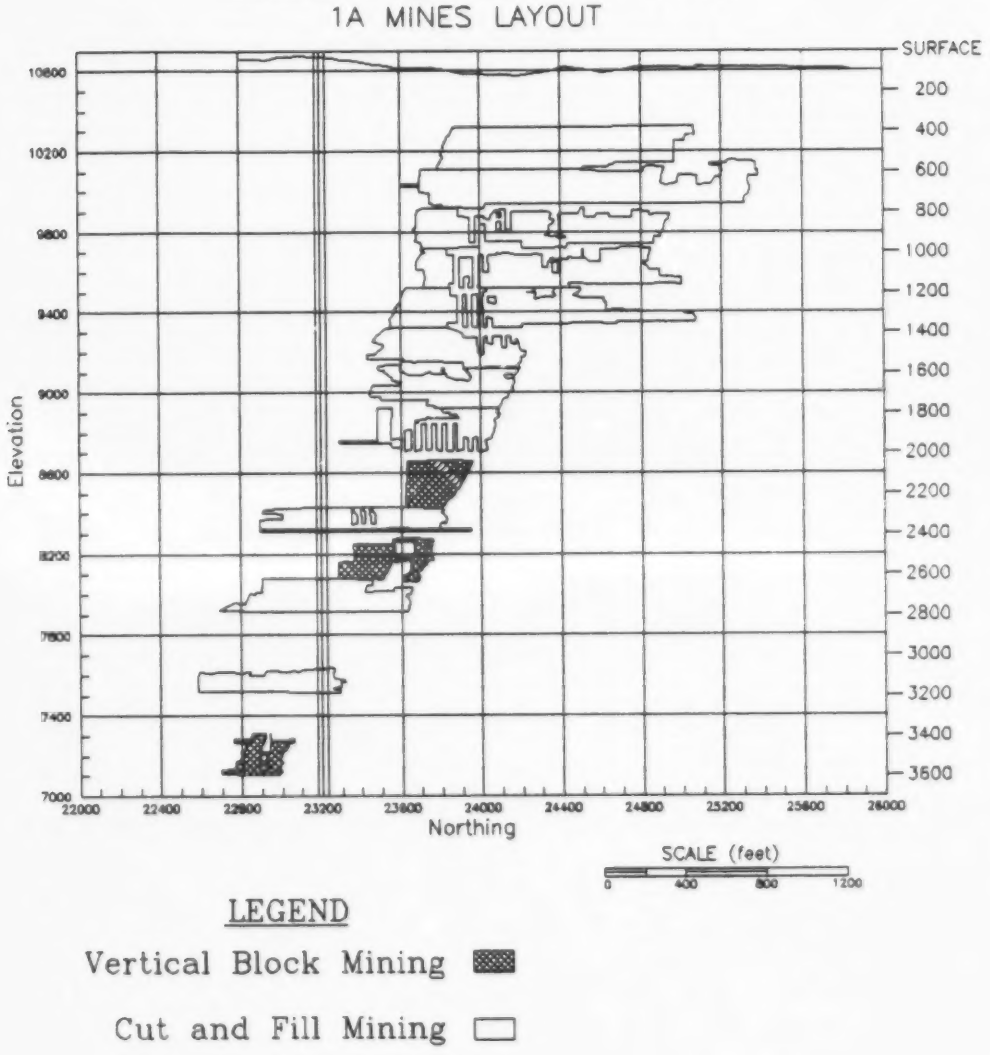


FIGURE 24C

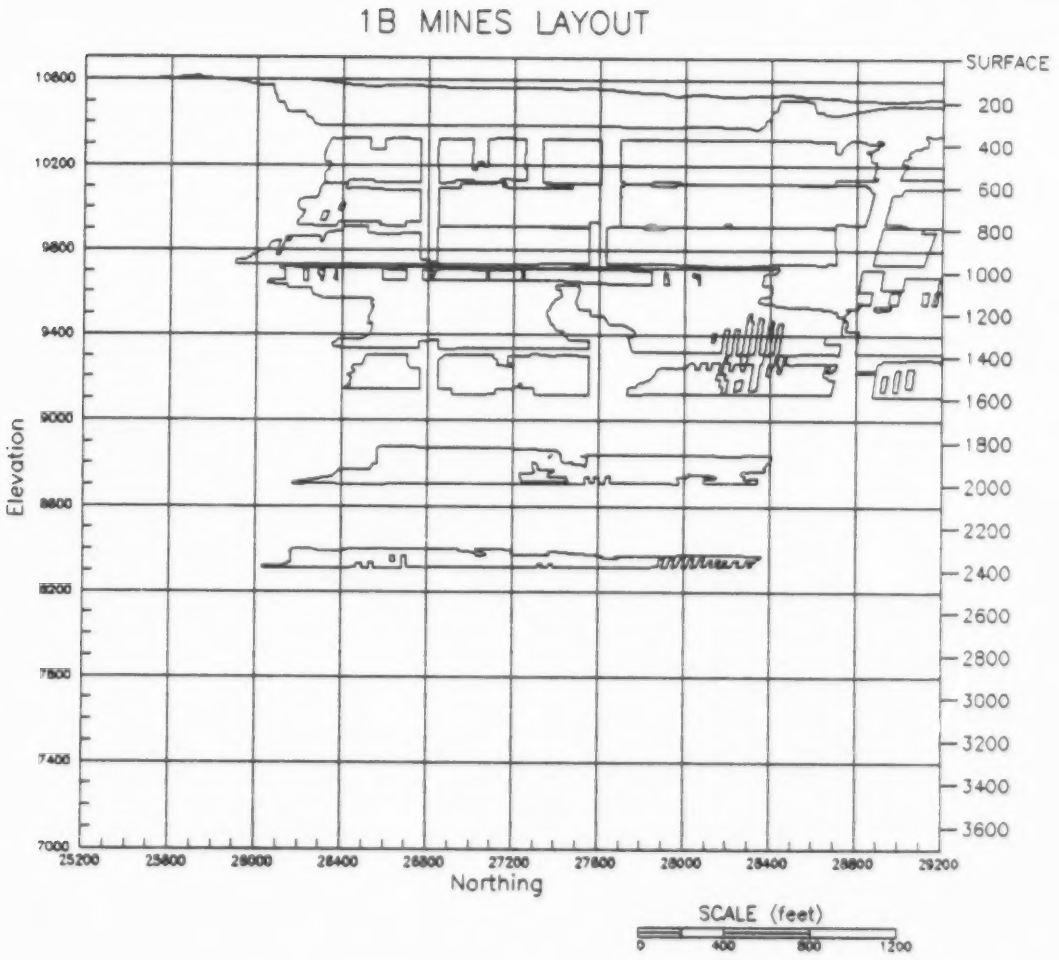

1B MINES LAYOUT
Elevation
10600
10200
9800
9400
9000
8600
8200
7800
7400
7000
SURFACE
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
3000
3200
3400
3600
25200
25600
26000
26400
26800
27200
27600
28000
28400
28800
29200
Northing
SCALE (feet)
0
400
800
1200

FIGURE 25A

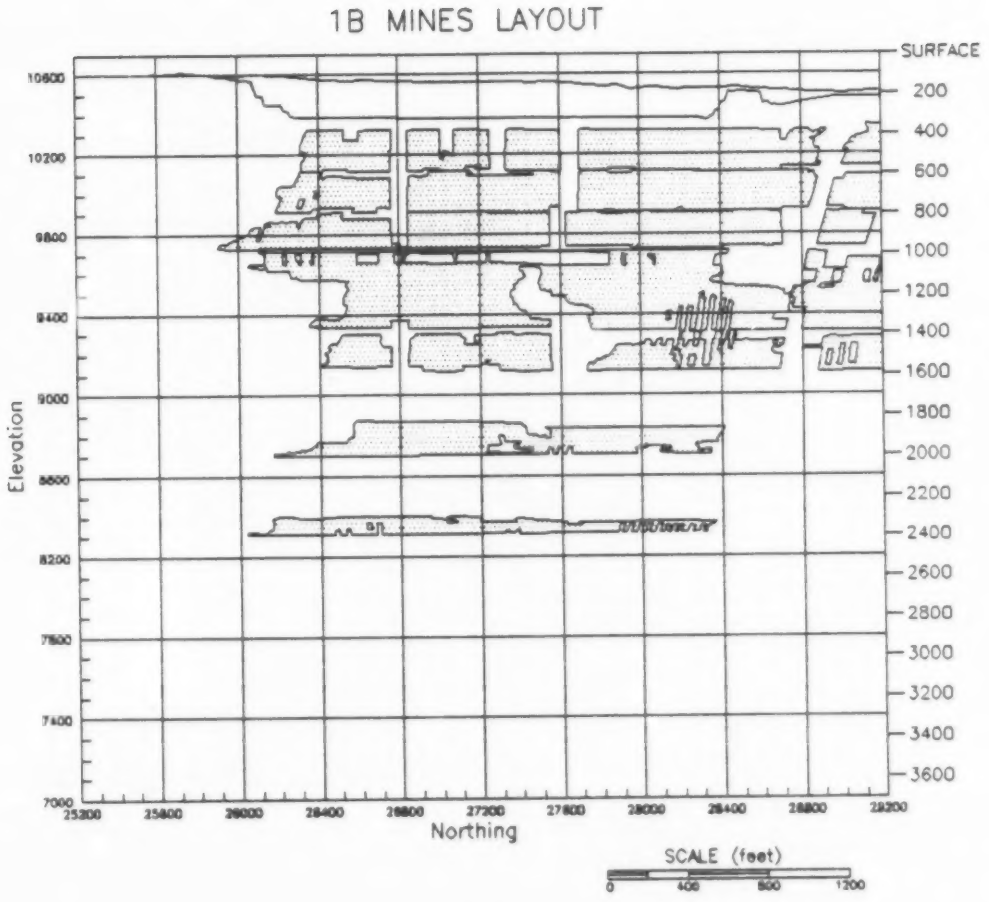

1B MINES LAYOUT
SURFACE
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
3000
3200
3400
3600
10600
10200
9800
9400
9000
8600
8200
7800
7400
7000
Elevation
25200
25600
26000
26400
26800
27200
27600
28000
28400
28800
29200
Northing
SCALE (feet)
0
400
800
1200

FIGURE 25

Mining Methods

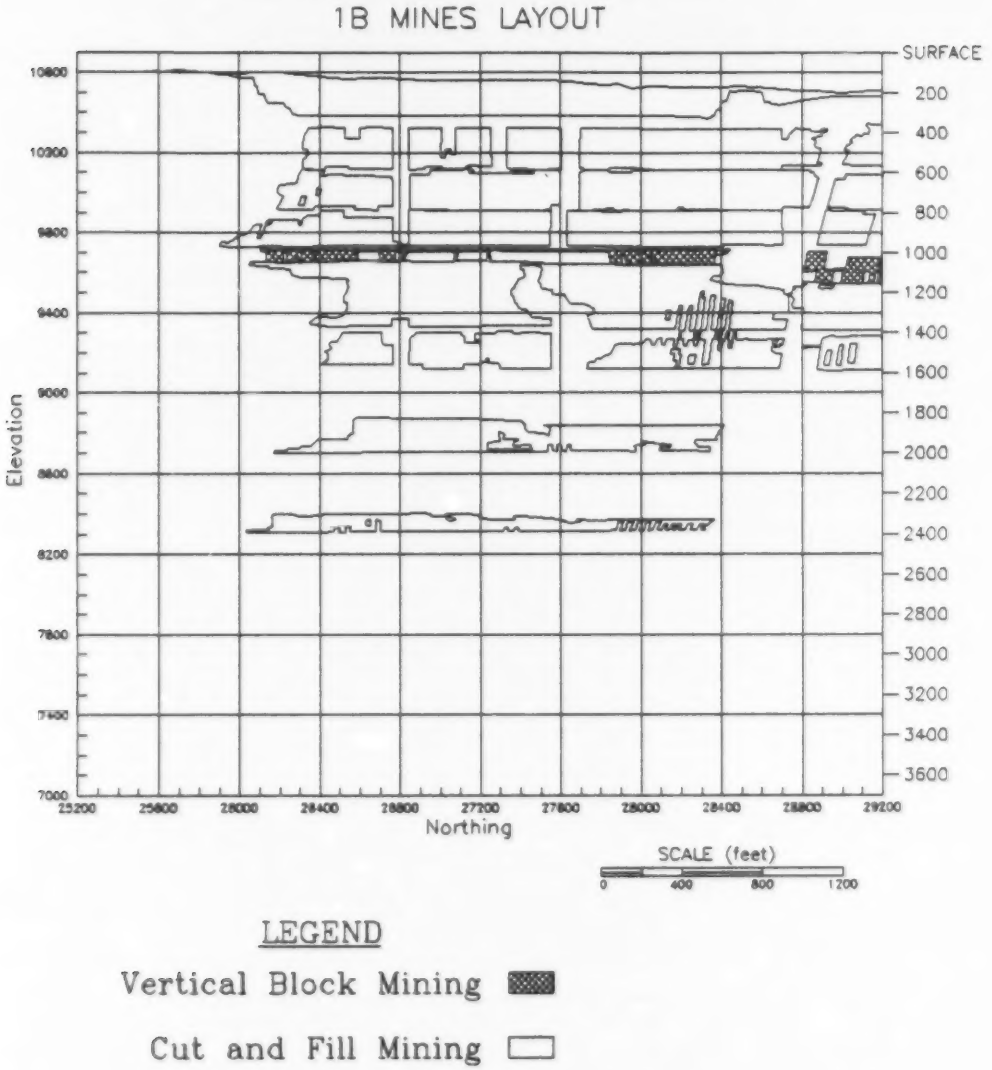


FIGURE 25C

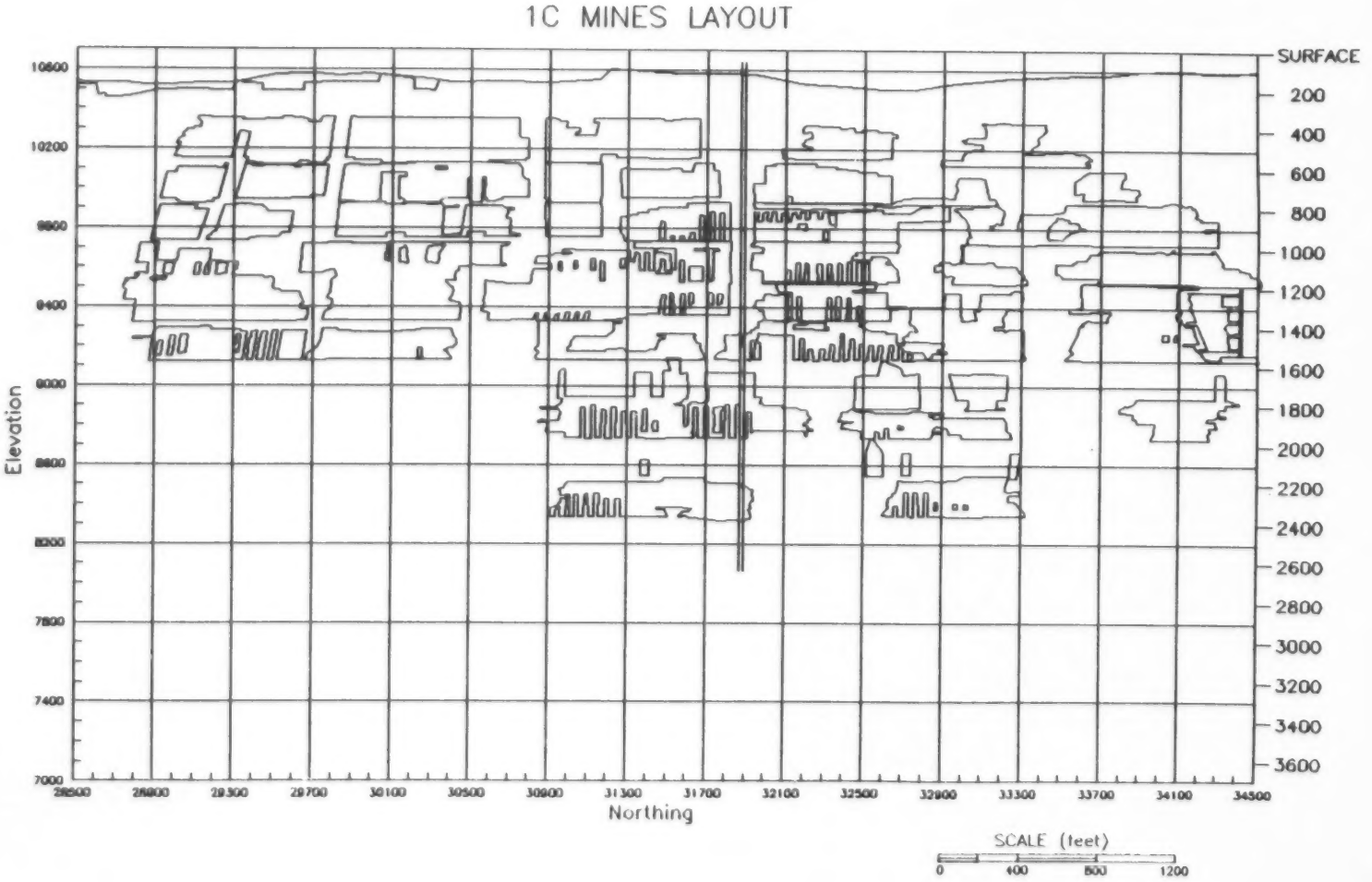

1C MINES LAYOUT
SURFACE
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
3000
3200
3400
3600
Elevation
10600
10200
9800
9400
9000
8600
8200
7800
7400
7000
28500
28900
29300
29700
30100
30500
30900
31300
31700
32100
32500
32900
33300
33700
34100
34500
Northing
SCALE (feet)
0
400
800
1200

FIGURE 26A

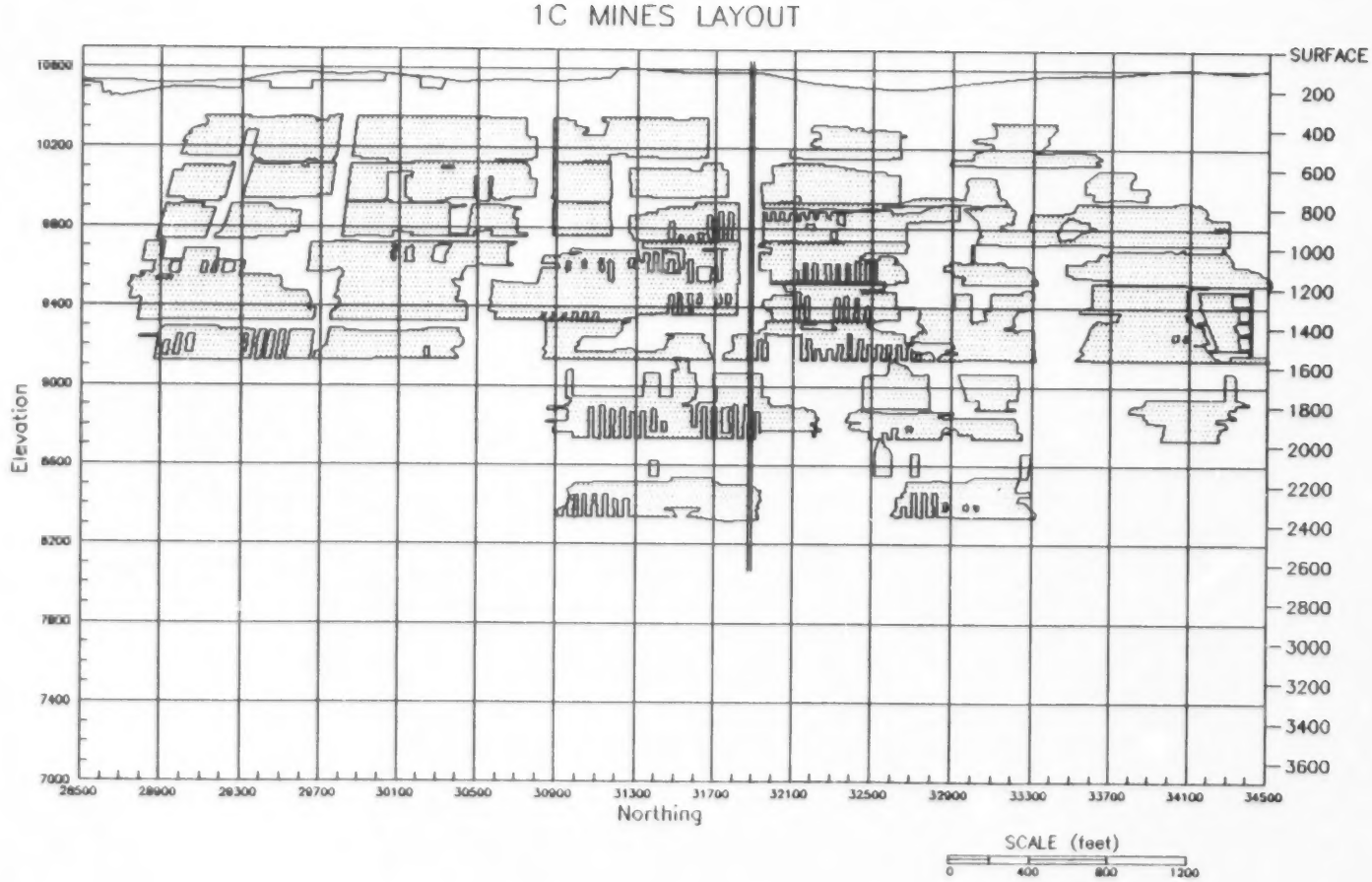

1C MINES LAYOUT
SURFACE
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
3000
3200
3400
3600
Elevation
10800
10200
9600
9400
9000
8600
8200
7800
7400
7000
28500
28900
29300
29700
30100
30500
30900
31300
31700
32100
32500
32900
33300
33700
34100
34500
Northing
SCALE (feet)
0
400
800
1200

FIGURE 28B

Mining Methods

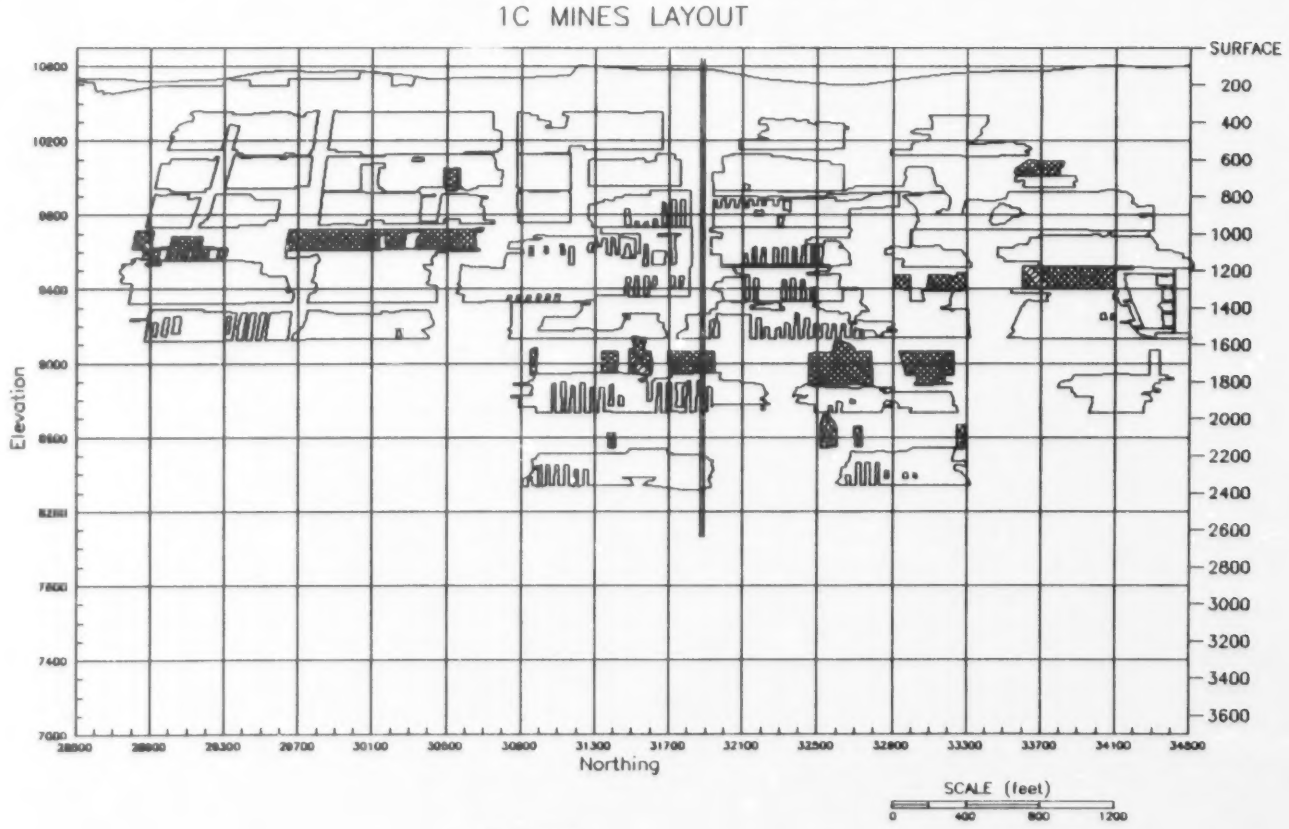
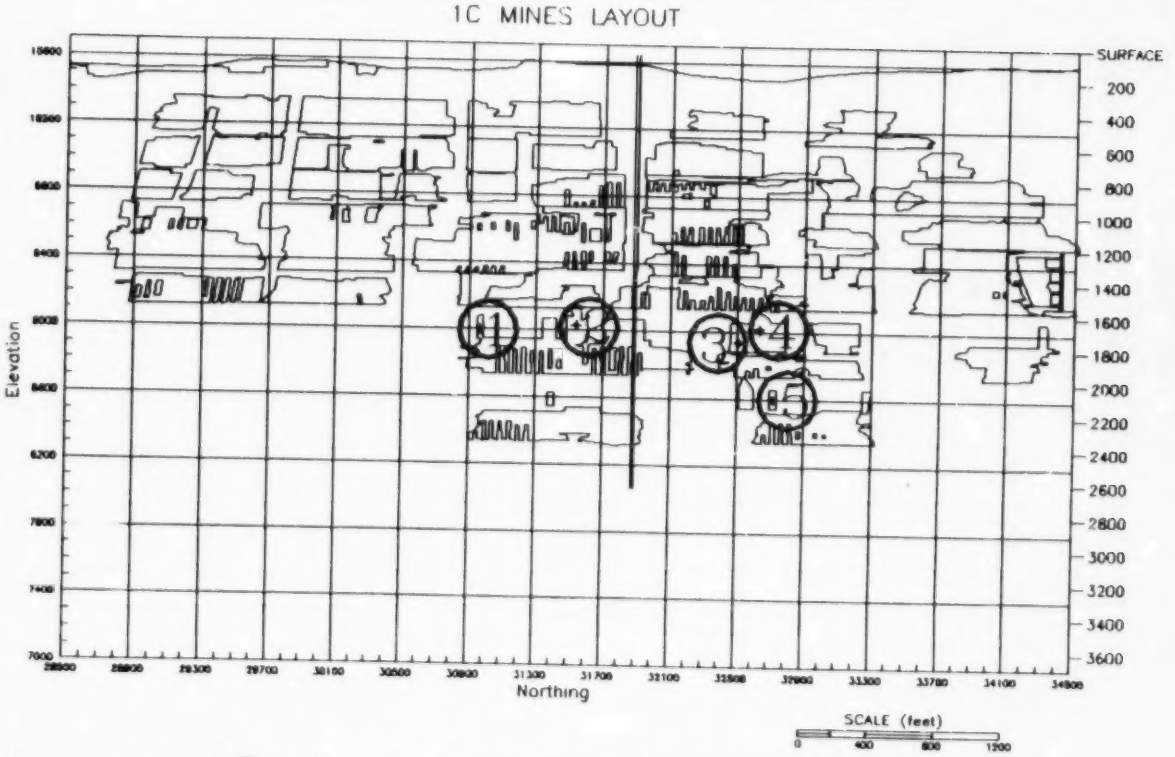


FIGURE 26C

Rock Failure Positions.



Position and Type of Failure

(1) 31,500 North, 1800 Level Stope. Block 2 Mechanical Anchor.
(2) 31,500 North, 1800 Level Stope. Block 8 Mechanical Anchor.
(3) 33,000 North, 1800 Level Stope. Block 6 Mechanical Anchor.
(4) 33,000 North, 1800 Level Stope. Block 8 Mechanical Anchor.
(5) 33,000 North, 2203 Level Stope. Block 1 Mechanical Anchor.

FIGURE 27

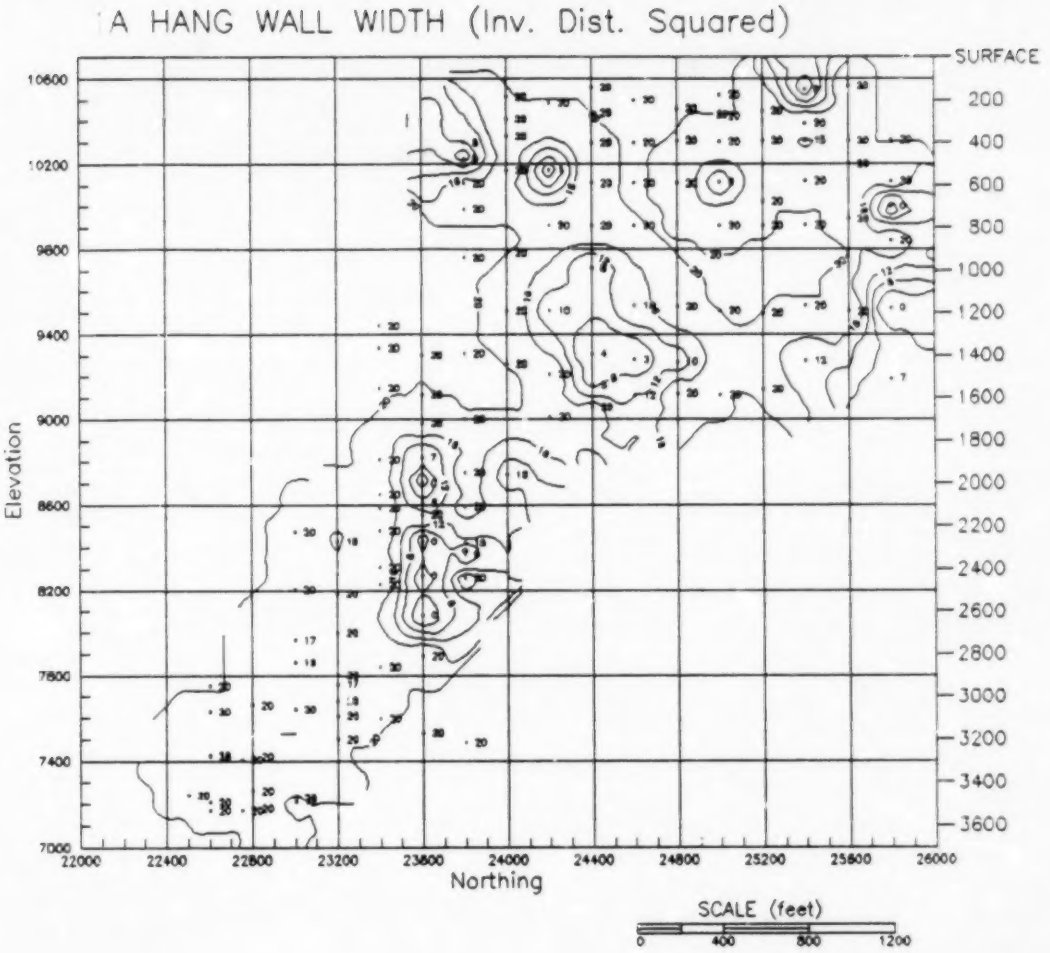

A HANG WALL WIDTH (Inv. Dist. Squared)
SURFACE
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
3000
3200
3400
3600
Elevation
10600
10200
9800
9400
9000
8600
8200
7800
7400
7000
22000
22400
22800
23200
23600
24000
24400
24800
25200
25600
26000
Northing
SCALE (feet)
0
400
800
1200

FIGURE 28A

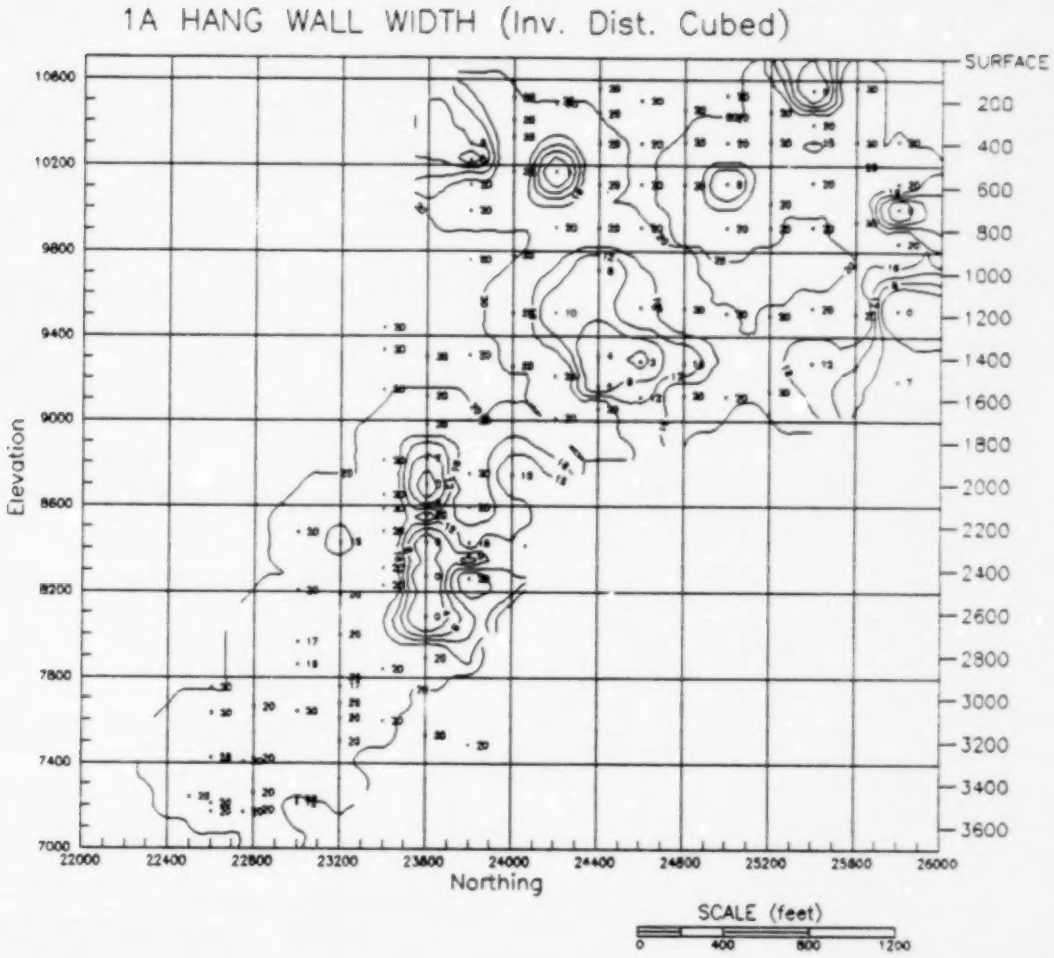

1A HANG WALL WIDTH (Inv. Dist. Cubed)
Elevation
Northing
SURFACE
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
3000
3200
3400
3600
10600
10200
9800
9400
9000
8600
8200
7800
7400
7000
22000
22400
22800
23200
23600
24000
24400
24800
25200
25800
26000
SCALE (feet)
0
400
800
1200

FIGURE 28B

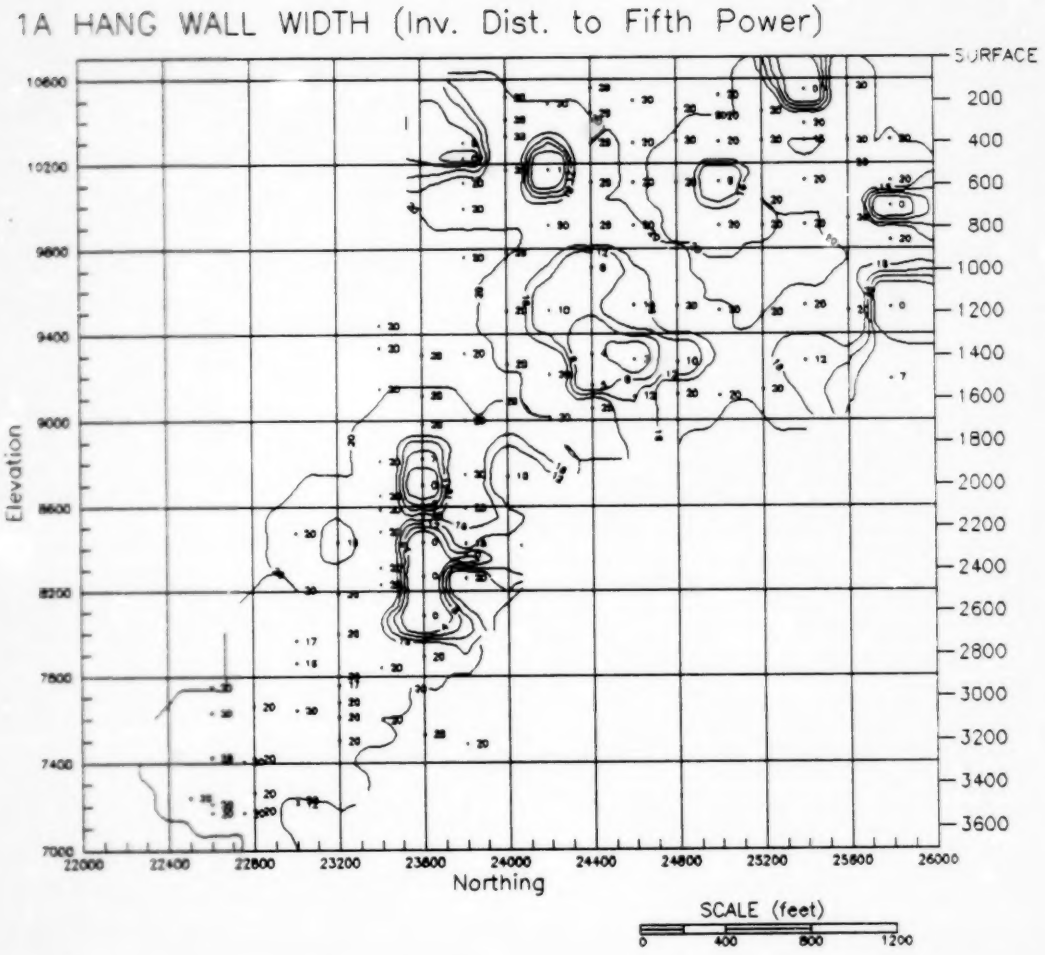

1A HANG WALL WIDTH (Inv. Dist. to Fifth Power)
SURFACE
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
3000
3200
3400
3600
10600
10200
9800
9400
9000
8600
8200
7800
7400
7000
Elevation
22000
22400
22800
23200
23600
24000
24400
24800
25200
25600
26000
Northing
SCALE (feet)
0
400
800
1200

FIGURE 28C

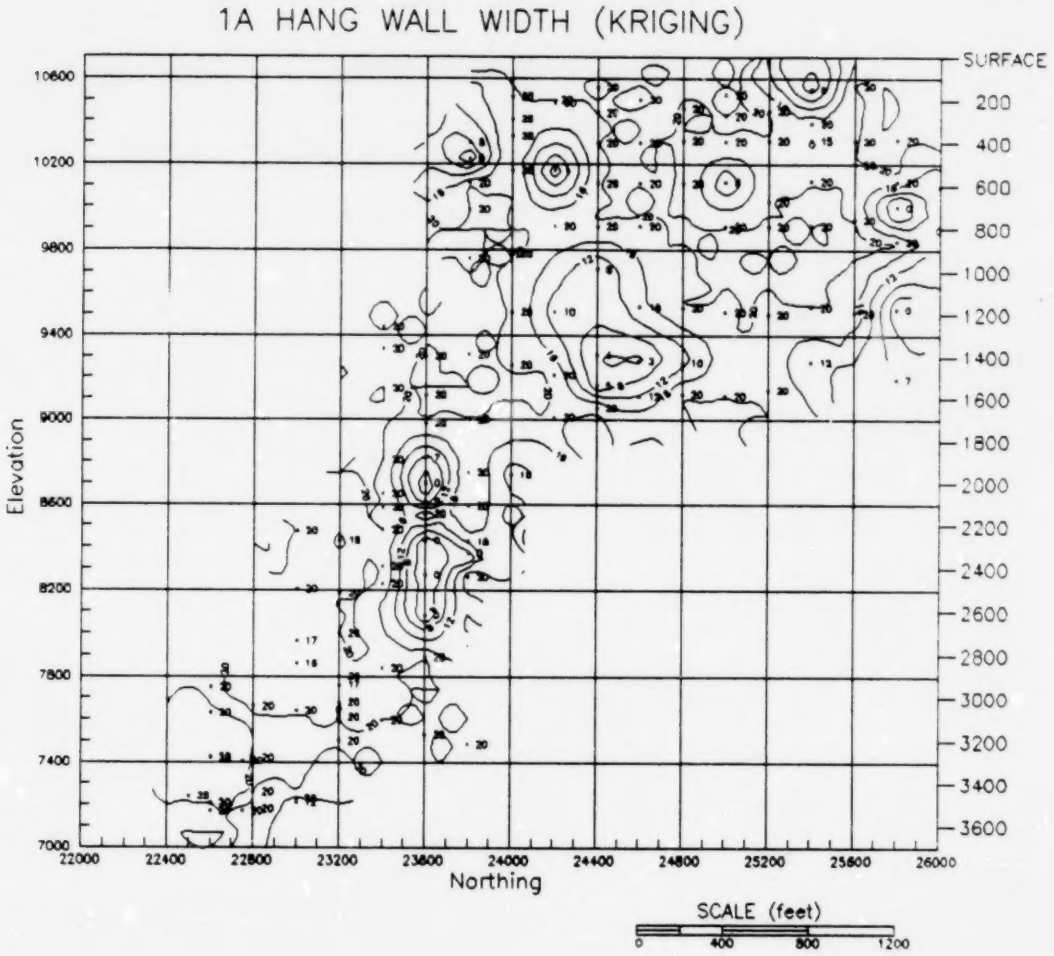

1A HANG WALL WIDTH (KRIGING)
Elevation
10600
10200
9800
9400
9000
8600
8200
7800
7400
7000
22000
22400
22800
23200
23600
24000
24400
24800
25200
25600
26000
Northing
SURFACE
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
3000
3200
3400
3600
SCALE (feet)
0
400
800
1200

FIGURE 28D

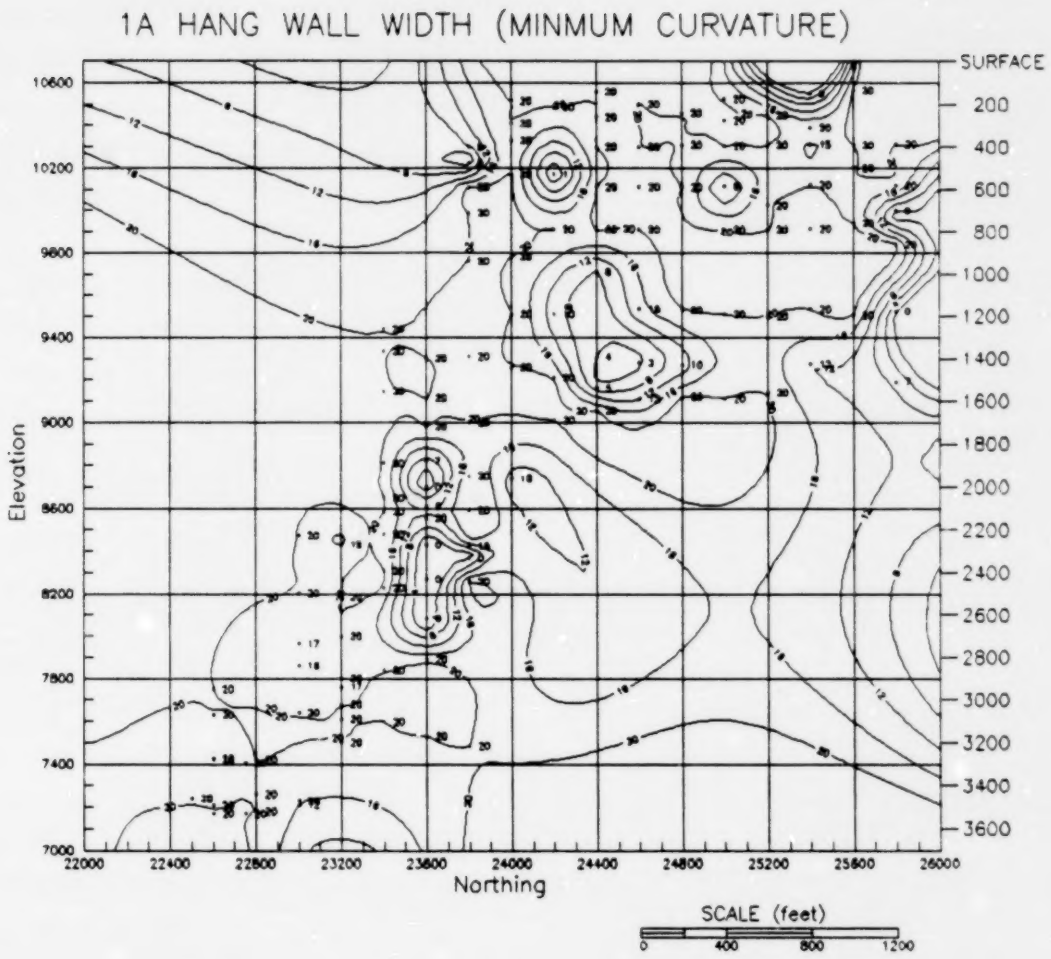

1A HANG WALL WIDTH (MINMUM CURVATURE)
SURFACE
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
3000
3200
3400
3600
Elevation
10600
10200
9800
9400
9000
8600
8200
7800
7400
7000
22000
22400
22800
23200
23600
24000
24400
24800
25200
25600
26000
Northing
SCALE (feet)
0
400
800
1200

FIGURE 28E

Table 1 Rock Mass Quality

Rock Type	RQD		Parameters					Rock Mass Quality (Q)	
	Mean	Range	Jn	Jr	Ja	Jw	SRF	Mean	Range
Biotite Gneiss	100	60-100	9	1.5	0.75	1	2	11	7-20
Amphibolite	70	10-100	9	1.5	0.75	1	2	8	1-11
Skarn (unleached)	80	30-100	9	1.5	0.75	1	2	9	3-11
Skarn (leached)	10	------	12	1.0	5.0	1	5	0.03	----
H.W. Quartzite	70	10-100	9	1.5	0.75	1	2	8	1-11
H.W. Schist	65	10-100	9	2.0	2.0	1	2	4	0.6-6
Ore Schist	55	10-100	9	1.5	1.0	1	2	5	0.8-8
F.W. Schist	30	10-100	9	1.5	2.0	1	2	1	0.4-4
F.W. Quartzite	50	10-100	9	2.0	0.75	1	2	7	1-15